Location of the Overton County (Tenn.) Railroad

E. A. Pratt

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Location of the Overton
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LOCATION OF THE OVERTON COUNTY RAILROAD

A THESIS

Presented By

Edmund A. Pratt.

To The

PRESIDENT AND FACULTY

of

ARMOUR INSTITUTE OF TECHNOLOGY

For The Degree Of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

Having Completed The Prescribed Course Of Study In

CIVIL ENGINEERING

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Location of the Overton County Railroad.

As an introduction to the real problem in the economic location of the Overton County Railroad it is not proposed to set forth all that which may be said to be definitely fixed in regard to the location of any railroad. It is true that each line is a distinct problem in itself, and even further than this, each division of a line is a separate problem in railroad location; and for this reason the premises upon which is based the decision in regard to any question are seldom, if ever, of such a nature as to warrant implicit trust in their veracity. If two railroads be built under what appear to be almost precisely the same conditions, but in different parts of the country, it has been found that the experience gained in locating the first is practically valueless as a criterion to aid in the location of the second. The poor location of many American railroads may be explained by the fact that the locating engineer seldom profits by the experience of others in his line of engineering, and is deprived almost entirely of the helpful checks which are afforded in such abundance to the designing or constructing engineer in the inspection and study of designs and plans which have been given material form. The problem confronting the locating engineer cannot be more clearly or concisely presented than in the way in which it is defined by the late E. M. Wellington in his masterpiece, "The Economic Theory of the Location of Railways". Mr. Wellington says: "Since there is no natural line between safety and danger to mark even so rude a distinction as that between

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the utterly bad and the barely tolerable, in the kind of engineering work we are to study, one may fairly say that the locating engineer has but one end before him to justify his existence as such---to get the most value for a dollar which nature permits; and but one failure to fear---that he will not do so.--XXXXXXXX--His true function and excuse for being as an engineer, as distinguished from a skilled workman, begins and ends in comprehending and striking a just balance between topographical possibilities, first cost, and future revenue and operating expenses."

First will be considered briefly the three principle factors affecting the problem, in the order above named, but separately; next, the three factors in their relations to each other will be studied; and finally, the most profitable way in which to proceed with the location, as suggested by all previous considerations, will be determined.

Topographical Possibilities:- To illustrate, suppose it is desired to locate a railroad between two cities, A and B. These points, A and B, will be called the primary controlling points.

The locating engineer determines from a map or otherwise the magnetic bearing of the straight line joining A and B. Starting at A he follows that course until B is reached, taking complete notes of obstacles which would probably deflect the line of road. Turning at B he returns to A on the side of the straight line joining A and B that seems to offer the most feasible route nearest to the straight line. When an obstacle is met it is explored on both sides for a

possible way to pass. On returning to A the engineer will possess sufficient information to enable him to locate approximately the probable secondary controlling points. The distances of the secondary controlling points from the straight line between A and B depends upon the difficulty of the country when gauged by the maximum gradient and the allowable sharpness of curvature, the estimated values of these quantities being known from the probable amount and kind of traffic, and the general topographical features of the region. Very often the most practicable river crossings and the most available saddles in the main divides between these rivers are controlling topographic points.

After the location of the secondary controlling points a topographic map may be made of that portion of the country through which the railroad will pass. The next step is that of fitting the road to the ground in the most economical manner, which is the object of this thesis for the case of the Overton County Railroad.

First Cost:- The first cost of a railroad depends upon the purpose for which it is to be used after construction. If light traffic and short trains are anticipated comparatively steep grades and moderately sharp curvature may be employed. However in the case of a road designed to carry coal or mineral ores the lowest possible grades and the easiest curvature practicable must be used.

Future Revenue and Operating Expenses:- The revenue of a railroad is proportional to the amount of traffic the road handles. Before locating a railroad an estimate is usually made of the amount of traffic the completed road can probably

procure, in order that those interested may know whether or not it will prove profitable to make the venture at all.

The operating expenses depend entirely upon the physical conditions of the road and the amount of traffic to be handled. The Interstate Commerce Commission makes a four-fold distribution of operating expenses, the aim being to divide the expenses into groups which are as mutually independent and distinct as possible. The groups are:

Average value

1. Maintenance of way and structures--------------20.[illegible]

   The values for five years have an extreme range of about 1.2%.

2. Maintenance of equipment------------------------16.[illegible]

   Extreme range of 1.834%. The tendency has been for this item to grow larger, not only in absolute amount but in percentage of total expenditures.

3. Conducting transportation----------------------57.793

   This item has been growing relatively less.

General expenses----------------------------------4.653

   A nearly constant item.

100.00%

It is remarkable that the cost per train mile on railroads in the United States is practically uniform. The table given on Plate I is from the report of the Interstate Commerce Commission for 1898 and shows very clearly this uniformity.

The average value of 95¢ per train mile will be used in

all calculations.

A detailed classification of operating expenses is given on Plate II. on account of it being necessary [illegible] to refer to these items by number and in groups as classified by the Interstate Commerce Commission. The table is from the report of the Interstate Commerce Commission for [illegible], pp. [illegible]-90.

Influence of Location on Operating Expenses:-Obviously it costs more to haul a given amount of traffic up steep grades and around sharp curves than to haul it over low grades and around long, easy curves. It is also clear that if the curvature and grades can be reduced so as to make it possible to dispense with, say, one train a day, on account of the increased hauling capacity of the other trains, the amount saved in a year may be considered available as interest on the money necessary to pay the increased cost of construction. In this manner distance, curvature, and grade may be reduced until the amount saved in operating expenses due to any change is not sufficient to pay interest on the additional capital required in order to make the change. When this stage is reached the location of the road may be considered to be the most economical for the given volume of traffic.

The three factors whose influence on operating expenses must be considered in detail are: (1) distance, (2) curvature, (3) grade.

Distance.

Not all the items in Table II. are affected by a change in distance, for instance the "general expenses" will

be unaffected. These items will not here be [illegible] separately but the effect on operating expenses of changes in distance (great and small) is very clearly shown in Table [illegible], Plate III, which is taken from Webb's "Railroad Construction", p.455.

Curvature.

The principle effect of curvature on the operation of trains is limiting the train length. The heaviest types of engines seem to give no considerable amount of difficulty on account of sharpness of curvature.

In regard to the relation of radius of curvature and of degree of central angle to operating expenses it has been found that a train running at average velocity on a 10° curve will encounter an additional resistance (due to curvature) equal to the average resistance found on a level tangent. Therefore on a 10° curve the resistance is doubled. It is also known that it is the central angle of the curve and not its degree which affects the resistance.

The following paragraph from Webb's "Railroad Construction", p. 450 illustrates the effect of curvature on operating expenses.

"A train mile costs about so much--approximately $1.00. Doubling the tractive resistance will increase certain items of expenditures about so much. This combined value is so much per cent of the cost of a train mile. A mile of continuous 10° curve contains 528° of central angle. A mile of such track would add so much per cent to the average train mile expense, and each degree of central angle is responsible for 1/528 of this increase. Since the increase is irrespective of radius and depends only on the degrees of central angle

we therefore say that each degree of central angle of curvature will add so much to the average operating expenses of a train mile".

Table IV, PlateIV, (Webb's "Railroad Construction") shows the effect on operating expenses of changes in curvature.

According to this table, 528° of curvature in one mile would increase the expenses of each train passing over it by 29.78% of the average cost of a train mile, and according to the general principles laid down in the preceding paragraph, 1° of central angle of any curve, no matter what the radius, will increase the expenses by 1/528 of 29.78% or 0.0564% per degree.

Compensation of ruling grades for curvature will be estimated from the following rules:

1. On the upper side of a stopping place for the heaviest trains compensate 0.10% per degree of curve.
2. On the lower side of a stopping place do not compensate at all.
3. Ordinarily compensate about 0.05% per degree of curve.
4. Reduce this rate to 0.04% or even 0.03% per degree of curve if the grade on tangents must be increased to reach the required summit.
5. Reduce the rate somewhat for curvature above 8° or 10°.
6. Curves on minor grades need not be compensated.

Grade.

Limiting grades only will be considered here as they are the only grades which limit the weight of trains which can be hauled by one engine.

The operating value of a reduction in the rate of the ruling grade is well shown by Table V, Plate IV, (Webb).

As an illustration, suppose the cost per train mile to be 95¢, and that 6 trains per day are required to haul the given traffic (1,700,000 tons per annum) over ruling grade of 2.00%. If the rate of ruling grade be reduced to 1.7% the number of trains per day required is reduced to 5 (See tabulation on p. 13), thus saving one train per day.

54.82% of 95¢ = 52.08¢ additional per train mile for the one train. Assuming the cost of additional engine to be $20,000, and its mileage life to be 800,000 miles (Wellington "Railway Location," p. 143). This gives 2.5¢ per mile. Adding this to the 52.08¢ gives 54.58¢ per day saved. The yearly saving is therefore $199.22. This capitalized at 5% is $3984.

Therefore if the reduction in ruling grade from 2.00% to 1.7% can be made for less than $3984 per mile the investment will prove profitable.

From what has been said it seems that the best manner in which to proceed with the location is to determine first the volume of traffic (tons per year) that is to be hauled, and then to choose a type of engine suitable for the work. Table VI, PlateV, gives the tractive power of various types of locomotives and will aid in the selection.

After the type of locomotive has been chosen its weight on the drivers and consequently its tractive power for different adhesion ratios is known (Table VI). Beginning with a ruling grade of, say, 2.00% the tractive resistance in pounds per ton is taken from Table VII, Plate V and the

net train load is calculated by subtracting the weight of engine and tender from the gross train load, which is found by dividing the tractive power of the locomotive by the tractive resistance, When the net train load is known, the number of trains per year, and therefore the number of trains per day, can be calculated. The number of trains per day for different rates of ruling grade should be calculated and tabulated as in table on page 13.

The next step is to locate a line on the topographic map which has for its ruling grade the highest which it is thought desirable to consider. In all probability this value of the rate of ruling grade is in excess of the one which will finally be adopted. The method of procedure of projecting the "paper location" is somewhat as follows; The projection should begin at the summit or other fixed point which the line must make. Setting a pair of dividers at the distance which the line rises or falls in one contour interval (as determined by the rate of grade), step off 10 or 12 inches on the map, following as nearly as possible the straight line between the controlling points but yet not exceeding the ruling grade. In favorable topography it is possible to step off quite a distance at once, stepping down one contour at a time, and marking by a small cross mark where the grade line crosses each. Since the rate of ruling grade is different on curves and on tangents it is necessary to reset the dividers when changing from curve to tangent, or vice versa.

The grade contour should then be very lightly pencilled in, and a curve or two, or a long tangent and the beginning

of one curve, projected. Then setting the dividers on the proper distance for the fall of one contour interval on the given curve or tangent, and starting from the given point, step along the projected location to the first point of curve and determine and write down its elevation to the nearest foot and tenth.

Having reached a curve from a tangent, reset the dividers for the proper distance for the given fall on the curve; starting from the P. C. step around the curve to the P. T., and determine and lightly note its elevation. Proceed in this manner to the end of the section projected.

Then return and correct the grade contour according to the precise points at which the elevation of each contour is reached on the actual projection, sketch all of it in, and see if the projection corresponds to the corrected grade contour as well as is possible. Consider everything; the material; the surface slope; the waterways; whether the line should be preferably in cut or fill; whether the tangent or the center of a curve cannot be slightly changed so as to fit the grade contour better, or avoid a rock cut; whether the form of the gulches is correctly represented and there is no a crossing point slightly more favorable above or below, which the topography does not clearly show; whether the tangent cannot be broken up by a slight curve and save work which will be more conspicuous on the ground than on the map; or, on the other hand, whether the line cannot be thrown out here and in there, so as to take out curvature and give as good a profile.

Only after another short stretch has been projected will

it be possible to correctly judge the preceding location.

After a considerable portion of the line has been located the stations are marked off and the elevation of each station plotted on the profile sheet.

Having made the profile the grades should be put on. A very important point is to keep the grade line well above the high water mark.

In the estimation of quantities for the purpose of comparing the advantages of alternate lines it is sufficiently accurate to compute the volumes by the method of average end areas. It is just as probable that the same error will occur in one portion of the line as in any other portion.

A considerable portion of the preceding instructions in regard to projecting location and estimating quantities was extracted from the chapters on "Projecting Location" and "Estimation of Quantities" in Wellington's "Economic Theory of the Location of Railways".

After one line with a given ruling grade has been located, and the estimate of quantities tabulated, another location is made in precisely the same manner except that the value of the rate of the ruling grade is lower. When the profile of this second line has been plotted and the quantities estimated the difference in cost of the two lines is computed. If the difference in cost is less than the capitalization of the saving due to reductions in distance, curvature, and grade a third line, having a still lower rate of ruling grade, should be located and this compared with the second line. This process is to be continued until the saving due to reductions in distance, curvature, and grade is not sufficient to pay

the interest on the additional capital required to make the improvements. The last line may be considered as the final location.

DATA.

The Overton County Railroad is to be built in the central part of Tennessee, and is to be used principally to haul coal.

The material to be excavated will be considered, for convenience of computation as well as lack of definite information on the subject, as 50% earth and 50% loose rock. No extraordinary construction being anticipated these percentages are sufficiently accurate for the purpose of comparison.

Following is a rough estimate of the cost per cubic yard of handling this material:

Loosening, with plough	1.50¢
Loading	5.25¢
Spreading	1.50¢
Wear, depreciation, etc.	0.25¢
Superintendence, etc.	1.50¢
Total per cubic yard	9.00¢
For ordinary haul	14.00¢
Cost of roadways	2.00¢
Total cost of handling one cubic yard	25.00¢

For the purpose of determining the most economic grades the tonnage is taken as 1,700,000 tons per year.

The type of engines which are to be used is the "consolidation". From Table VI, Plate V, the total weight of engine and tender is seen to be 324,800 pounds (162.4 tons), the

weight on drivers is 181,200 pounds. For adhesion ratio of 1/4 tractive force of engine is 45,300 pounds. Assuming tractive resistance on the level as 6 pounds per ton the following table was computed for different grades within the probable limits:

Grade	Trains	
%	Per year.	Per day
2.0	2168	6
1.7	1836	5
1.4	1520	4
1.1	1221	3

After locating one line and plotting the profile, using a rate of ruling grade of 2.0%, the rate of grade was reduced to 1.4% and the new profile plotted.

The quantities of material to be excavated and required for embankment are tabulated on Plate VI for both lines. It is seen that the cost of reducing the rate of ruling grade from 2% to 1.4% will come under $50,000. Since two trains per day are dispensed with, the saving is $398.44 per year per mile. This capitalized at 5% gives $7,969.00.

For 51,000 ft. of line: $\frac{51,000}{5280} \times \$7,969.00 = \$77,000.00$

Therefore, since the cost of lowering the gradient is only $50,000.00, the investment will prove profitable.

From an inspection of the profile it is obvious that to reduce the gradient to 1.1% (saving one more train per day) would require excessive excavation and would not be economical.

TABLE I.

PLATE I.

COST PER TRAIN-MILE

Number in Report.		Mileage.	Operating expenses per train-mile.	Ratio $\frac{\text{exp.}}{\text{earn.}}$
	Whole United States	186,396	0.956	65.5
71	Canadian Pacific	6,568	0.854	58.3
1466	C., M., & St. P.	6,191	0.883	58.
1443	C., B., & Q.	6,860	0.881	60.
1879	Southern Pacific	6,426	1.320	68.7
1142	Southern	5,232	0.809	65.52
1436	Chicago & Northwestern	6,086	0.885	63.3
1405	A., T., & S.F.	4,565	0.917	67.5
1560	Northern Pacific	4,524	1.177	46.
1495	Great Northern	3,860	1.101	46.9
1264	Illinois Central	3,807	0.764	63.56
	Average of ten		0.969	59.0

Year.	Average cost per train-mile.
1890	96.006 ¢
1891	95.707
1892	96.580
1893	97.272
1894	93.478
1895	91.829
1896	93.838
1897	92.918
1898	95.635
1899	98.390
	95.165 ¢

Location of Overton County R.R.

E. C. Pratt.

Total	$ 464,950,584	57.031	57.194	57.920	57.362	59.460
General expenses:						
47. Salaries of general officers	$ 9,535,48[illegible]	[illegible]71	1.165	1.235	1.213	1.333
48. Salaries of clerks and attendants	10,864,401	1.334	1.334	1.368	1.409	1.385
49. General office expenses and supplies	2,373,912	0.292	0.285	0.301	0.311	0.316
50. Insurance	3,052,585	0.372	0.395	0.436	0.446	0.487
51. Law expenses	5,783,372	0.710	0.655	0.791	0.725	0.806
52. Stationery and printing (general offices)	1,390,670	0.171	0.176	0.163	0.165	0.172
53. Other expenses	3,838,987	0.471	0.409	0.462	0.344	0.457
Total	$ 36,819,716	4.521	4.419	4.758	4.613	4.955
Recapitulation of expenses:						
54. Maintenance of way and structures	$ 169,925,054	20.853	21.028	20.972	20.654	19.824
55. Maintenance of equipment	143,294,445	17.595	17.359	16.352	17.391	15.761
	[illegible]	57.031	57.194	57.920	57.362	59.460

TABLE II. SUMMARY SHOWING CLASSIFICATION OF OPERATING EXPENSES. PLATE II.

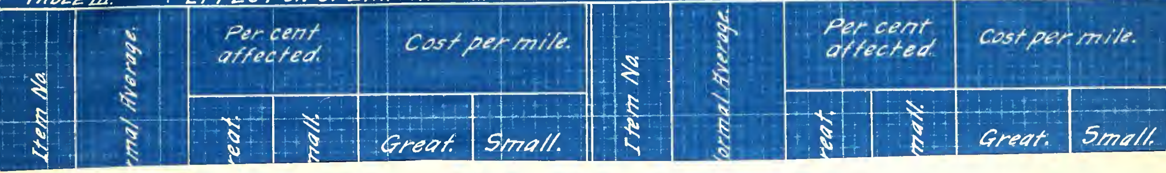
Item.	Amount.	Per cent				
	1899	1899	1898 a	1897 b	1896 c	1895 d
Maintenance of way and structures:						
1. Repairs of roadway	$87,307,140	10.720	10.643	10.649	10.738	11.235
2. Renewals of rails	10,767,381	1.322	1.391	1.596	1.449	1.491
3. Renewals of ties	23,623,325	2.901	3.232	3.357	3.028	2.441
4. Repairs and renewals of bridges and culverts	19,335,860	2.374	2.512	2.472	2.265	2.241
5. Repairs and renewals of fences, road crossings, signs, and cattle guards	3,968,408	0.487	0.537	0.509	0.501	0.529
6. Repairs and renewals of buildings and fixtures	17,762,120	2.181	1.957	1.745	1.799	1.643
7. Repairs and renewals of docks and wharves	2,070,098	0.254	0.245	0.231	0.270	0.255
8. Repairs and renewals of telegraph	1,153,408	0.142	0.137	0.126	0.135	0.134
9. Stationery and printing	208,775	0.026	0.025	0.029	0.027	0.033
10. Other expenses	3,628,539	0.446	0.349	0.318	0.372	0.304
Total	$169,825,059	20.858	21.028	20.972	20.654	19.824
Maintenance of equipment:						
11. Superintendence	$5,147,586	0.632	0.656	0.667	0.666	0.629
12. Repairs and renewals of locomotives	50,555,269	6.208	5.887	5.663	5.978	5.660
13. " " passenger cars	17,623,134	2.164	2.188	2.265	2.216	2.211
14. " " freight cars	57,320,521	7.038	7.210	6.376	7.193	6.008
15. " " work cars	1,708,416	0.210	0.159	0.140	0.145	0.121
16. " " marine equipment	2,012,478	0.247	0.242	0.215	0.173	0.167
17. " " shop machinery and tools	4,167,798	0.512	0.486	0.478	0.520	0.455
18. Stationery and printing	329,261	0.040	0.038	0.039	0.040	0.041
19. Other expenses	4,429,987	0.549	0.493	0.509	0.460	0.469
Total	$143,294,445	17.595	17.359	16.352	17.391	15.761
Conducting transportation:						
20. Superintendence	$14,392,691	1.767	1.749	1.895	1.731	1.718
21. Engine and roundhouse men	78,913,978	9.690	9.645	9.922	9.733	9.917
22. Fuel for locomotives	77,187,349	9.478	9.457	9.669	9.669	10.408
23. Water supply for locomotives	5,038,615	0.619	0.646	0.677	0.691	0.724
24. Oil, tallow, and waste for locomotives	2,922,095	0.359	0.355	0.379	0.377	0.413
25. Other supplies for locomotives	1,438,054	0.177	0.156	0.160	0.229	0.200
26. Train service	61,756,607	7.583	7.660	7.589	7.789	7.993
27. Train supplies and expenses	12,439,675	1.527	1.528	1.508	1.556	1.526
28. Switchmen, flagmen, and watchmen	33,791,385	4.149	4.080	4.171	4.120	4.160
29. Telegraph expenses	15,525,232	1.906	1.907	2.000	1.978	2.078
30. Station service	61,160,732	7.510	7.758	8.002	7.710	8.112
31. Station supplies	5,664,095	0.696	0.692	0.751	0.794	0.876
32. Switching charges, balance	2,895,893	0.356	0.371	0.327	0.356	0.349
33. Car mileage, balance	16,367,903	2.010	2.107	2.203	2.059	2.096
34. Hire of equipment, balance	2,993,088	0.368	0.342	0.249	0.322	0.384
35. Loss and damage	5,976,082	0.734	0.706	0.692	0.775	0.784
36. Injuries to persons	7,116,212	0.874	0.882	0.879	0.840	0.945
37. Clearing wrecks	1,197,901	0.147	0.130	0.123	0.126	0.130
38. Operating marine equipment	7,065,668	0.868	0.958	0.939	0.826	0.848
39. Advertising	3,569,073	0.438	0.417	0.428	0.417	0.429
40. Outside agencies	14,507,499	1.781	1.762	1.727	1.567	1.623
41. Commissions	1,580,909	0.194	0.181	0.158	0.168	0.154
42. Stockyards and elevators	936,979	0.115	0.185	0.140	0.126	0.116
43. Rents for tracks, yards, and terminals	15,482,170	1.901	1.914	1.953	1.746	1.727
44. Rents for buildings and other property	3,967,353	0.487	0.475	0.501	0.502	0.497
45. Stationery and printing	5,107,066	0.627	0.583	0.633	0.616	0.589
46. Other expenses	5,456,377	0.670	0.624	0.587	0.597	0.669
Total	$469,950,584	57.031	57.194	57.920	57.362	59.460
General expenses:						
47. Salaries of general officers	$9,535,486	1.171	1.165	1.235	1.218	1.333
48. Salaries of clerks and attendants	10,864,401	1.334	1.339	1.368	1.409	1.385
49. General office expenses and supplies	2,373,912	0.292	0.285	0.301	0.311	0.316
50. Insurance	3,032,888	0.372	0.395	0.436	0.446	0.487
51. Law expenses	5,783,372	0.710	0.655	0.791	0.725	0.806
52. Stationery and printing (general offices)	1,390,670	0.171	0.176	0.163	0.165	0.172
53. Other expenses	3,838,987	0.471	0.409	0.462	0.349	0.457
Total	$36,819,716	4.521	4.419	4.756	4.613	4.955
Recapitulation of expenses:						
54. Maintenance of way and structures	$169,825,059	20.858	21.028	20.972	20.634	19.824
55. Maintenance of equipment	143,294,445	17.595	17.359	16.352	17.391	15.761
56. Conducting transportation	469,450,589	57.031	57.194	57.920	57.362	59.460
57. General expenses	36,819,716	4.521	4.419	4.756	4.613	4.955
Grand total e	$819,389,799	100.000	100.000	100.000	100.000	100.000

a Based on $704,332,4[illegible], excluding $[illegible] 376 unclassified.
b " " 642,400,657 " 60,083,127 "
c " " 721,552,768 " 51,258,215 "
d " " 775,228,440 " 60,461,775 "
e Excludes $12,579,147 unclassified.

Location of Overton County R.R.

E.A.Pratt.

TABLE III. . EFFECT ON OPERATING EXPENSES OF CHANGES IN DISTANCE PLATE III.



Item No.	rmal Average.	Per cent affected.		Cost per mile.		Item No.	ormal Average.	Per cent affected.		Cost per mile.	
		reat.	mall.	Great.	Small.			reat.	mall.	Great.	Small.

TABLE III.

EFFECT ON OPERATING EXPENSES OF CHANGES IN DISTANCE

PLATE III.

Item No.	Normal Average.	Per cent affected.		Cost per mile.	
		Great.	Small.	Great.	Small.
1	10.596	100	100	10.60	10.60
2	1.440	100	100	1.44	1.44
3	3.093	100	100	3.09	3.09
4	2.378	100	0	2.38	0.00
5	0.523	100	100	0.52	0.52
6	1.865	30	0	0.56	0.00
7	0.247	0	0	0.00	0.00
8	0.135	60	60	0.08	0.08
9	0.027	100	0	0.03	0.00
10	0.358	100	0	0.36	0.00
	20.662			18.94	15.61
11	0.650	50	0	0.32	0.00
12	5.879	42	42	2.47	2.47
13	2.209	36	36	0.80	0.80
14	6.765	36	36	2.44	2.44
15	0.155	100	50	0.15	0.08
16	0.209	0	0	0.00	0.00
17	0.490	100	50	0.49	0.25
18	0.040	100	50	0.04	0.02
19	0.495	100	50	0.50	0.25
	16.892			7.21	6.31
20	1.761	0	0	0.00	0.00
21	9.781	93	0	9.10	0.00
22	9.681	55	55	5.32	5.32
23	0.671	50	50	0.34	0.34
24	0.276	50	50	0.19	0.19
25	0.189	50	50	0.09	0.09
	22.454			15.04	5.94

Item No.	Normal Average.	Per cent affected.		Cost per mile.	
		Great.	Small.	Great.	Small.
	22.454			15.04	5.94
26	7.722	100	0	7.72	0.00
27	1.528	50	50	0.76	0.76
28	4.136	50	50	2.07	2.07
29	1.974	20	20	0.39	0.39
30	7.818	0	0	0.00	0.00
31	0.762	0	0	0.00	0.00
32	0.345	0	0	0.00	0.00
33	2.094	100	100	2.09	2.09
34	0.333	0	0	0.00	0.00
35	0.738	100	100	0.74	0.74
36	0.883	100	100	0.88	0.88
37	0.131	100	100	0.13	0.13
38	0.887	0	0	0.00	0.00
39	0.426				
40	1.692				
41	0.171				
42	0.130				
43	1.848				
44	0.492				
45	0.610				
46	0.619				
	57.793			29.82	13.00
47	4.653	0	0	0.00	0.00
48					
49					
50					
51					
52					
53					
	100.000			55.97	34.92

Location of Overton County R.R.

E. A. Pratt.

EFFECT ON
OF CHANG
TABLE IV.

Item No.	Normal averag
1	10.59
2	1.94
3	3.09
4 10	5.53
	20.66
11	0.65
12	5.879
13	2.20
14	6.765
15	0.155
16	0.209
17	0.49
18	0.04
19	0.495
	16.892
20	1.761
21	9.781
22	9.681
23	0.671
24	0.376
25	0.18
26 46	35.34
	57.79
47 53	4.65
	100.0

EFFECT ON OPERATING EXPENSES OF CHANGES IN CURVATURE.

TABLE IV.

Item No.	Normal average.	Per cent affected.	Cost per mi. per cent.
1	10.596	25	2.649
2	1.440	300	4.320
3	3.093	50	1.546
4 10	5.533	0	0.0
	20.662		8.515
11	0.650	0	0.0
12	5.879	100	5.879
13	2.209	100	2.209
14	6.765	100	6.765
15	0.155	100	0.155
16	0.209	0	0.000
17	0.490	50	0.245
18	0.040	0	0.0
19	0.495	0	0.0
	16.892		15.253
20	1.761	0	0.0
21	9.781	0	0.0
22	9.681	55	5.335
23	0.671	55	0.369
24	0.376	55	0.207
25	0.184	55	0.101
26 46	35.340	0	0.0
	57.794		6.012
47 53	4.653	0	0.0
	100.000		29.780

EFFECT ON OPERATING EXPENSES OF CHANGES IN GRADE.

TABLE V.

Item No.	Normal average.	Per cent affected.	Cost per cent.
1	10.596	12.5	1.32
2	1.440	50	0.72
3	3.093	50	1.55
4-10	5.533	0	0.0
	20.662		3.59
11	0.650	0	0.0
12	5.879	80	4.70
13	2.209	5	0.11
14	6.765	10	0.68
15-19	1.389	0	0.0
	16.892		3.91
20	1.761	100	1.76
21	9.781	100	9.78
22-25	10.912	75	8.18
26-32	24.285	100	24.28
33	2.094	0	0.00
34-37	2.085	100	2.09
38-44	5.696	0	0.00
45-46	1.229	100	1.23
	57.793		47.32
47-53	4.653	0	0.0
	100.000		54.82

Location of Overton County R.R.

E.C. Pratt

TABLE VI.

TRACTI

RESISTANCE GRADES.

Kind.	Gauge.	Tractive res. on level.[a]		
		6	7	8
		27	28	29
American	Nar.	28	29	30
"	"	29	30	31
Mogul	"	30	31	32
10-Wheel	"	31	32	33
Consol.	"	32	33	34
"	"	33	34	35
		34	35	36
American	Stand.	35	36	37
"Chautau"	"	36	37	38
Mogul	"	37	38	39
		38	39	40
10-wheel	"	39	40	41
Consol	"	40	41	42
"	"	41	42	43
		42	43	44
		43	44	45
		44	45	46
		45	46	47
		46	47	48
		47	48	49
		48	49	50
		49	50	51
		50	51	52
		51	52	53

[a] lbs. per ton.

TABLE V.

TRACTIVE POWER OF VARIOUS TYPES OF LOCOMOTIVES.

Kind.	Gauge.	Total weight of engine & tender. lbs.	Total weight of engine & tender. tons.	Weight of engine only.	Weight on drivers.	Tractive power when rate of adhesion is $\frac{1}{4}$	Tractive power when rate of adhesion is $\frac{9}{40}$	Tractive power when rate of adhesion is $\frac{1}{5}$
American	Nar.	49,000	24.5	32,000	22,000	5500	4,950	4,400
"	"	80,000	40.0	49,000	32,000	8,000	7,200	6,400
Mogul	"	81,000	40.5	51,000	42,000	10,500	9,450	8,400
10-Wheel	"	87,000	43.5	55,000	42,000	10,500	9,450	8,400
Consol.	"	62,000	31.0	39,000	34,000	8,500	7,650	6,800
"	"	144,000	72.0	94,000	84,000	21,000	18,900	16,800
American	Stand.	104,000	52.0	62,000	40,000	10,000	9,000	8,000
"Chautau"	"	314,600	157.3	190,600	99,400	24,850	22,365	19,880
Mogul	"	206,000	103.0	126,000	106,400	26,600	23,940	21,280
10-Wheel	"	276,000	138.0	176,510	127,010	31,752	28,577	25,402
Consol	"	214,000	107.0	120,000	106,000	26,500	23,850	21,200
"	"	324,800	162.4	204,800	181,200	45,300	40,770	36,240

TABLE VI.

TOTAL TRAIN RESISTANCE ON VARIOUS GRADES.

Grade Rate %	Grade Ft. per mi.	Tractive res. on level.[a] 6	Tractive res. on level.[a] 7	Tractive res. on level.[a] 8
1.05	55.44	27	28	29
.10	58.08	28	29	30
.15	60.72	29	30	31
.20	63.36	30	31	32
.25	66.00	31	32	33
1.30	68.64	32	33	34
.35	71.28	33	34	35
.40	73.92	34	35	36
.45	76.56	35	36	37
.50	79.20	36	37	38
1.55	81.84	37	38	39
.60	84.48	38	39	40
.65	87.12	39	40	41
.70	89.76	40	41	42
.75	92.40	41	42	43
1.80	95.04	42	43	44
.85	97.68	43	44	45
.90	100.32	44	45	46
.95	102.96	45	46	47
2.00	105.60	46	47	48
2.05	108.24	47	48	49
.10	110.88	48	49	50
.15	113.52	49	50	51
.20	116.16	50	51	52
.25	118.80	51	52	53

[a] lbs. per ton.

PLATE V

Location of Overton County R.R.

E. C. Prall.

Line "A"
Line "B"

PLATE VI.

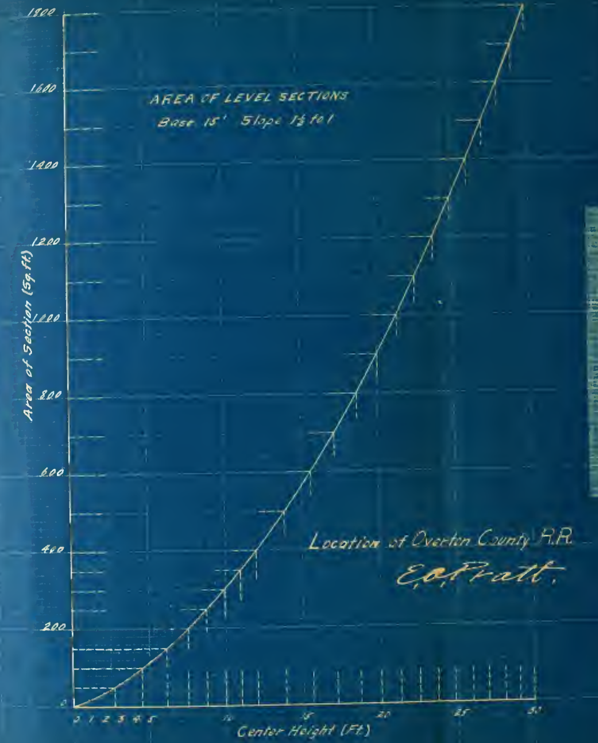
Comparison of Quantities.

	Section	Embankment Cu. yds.	Excavation Cu. yds.	Borrow or Waste	Cubic yards at 25¢
Line "A"	1	17168	25944	8776	25944
	2	32921	34311	1390	34311
	3	47447	53191	5744	53191
	4	71906	94433	22527	94433
	5	8756	7006	1750	8756
	6	7496	13716	6220	13716
	7	7516	7707	191	7707
	8	22343	20239	2104	22343
	9	13006	10671	2335	13006
	10	7725	5914	1811	7725
				Total	291,635
Line "B"	1	26906	27341	435	27341
	2	44067	30700	13367	44067
	3	150500	16556	133944	150500
	4	30454	104067	73613	104067
	5	28517	3346	25171	28517
	6	7496	13716	6220	13716
	7	7516	7707	191	7707
	8	22343	20239	2104	22343
	9	37111	8207	28904	37111
	10	13667	48376	34709	48376
				Total	485,765
					291,635
					194,130

194130 Cu yds
@ 25¢
= $48532

Location of Overton County R.R.

E. A. Pratt



Location of Overton County R.R.

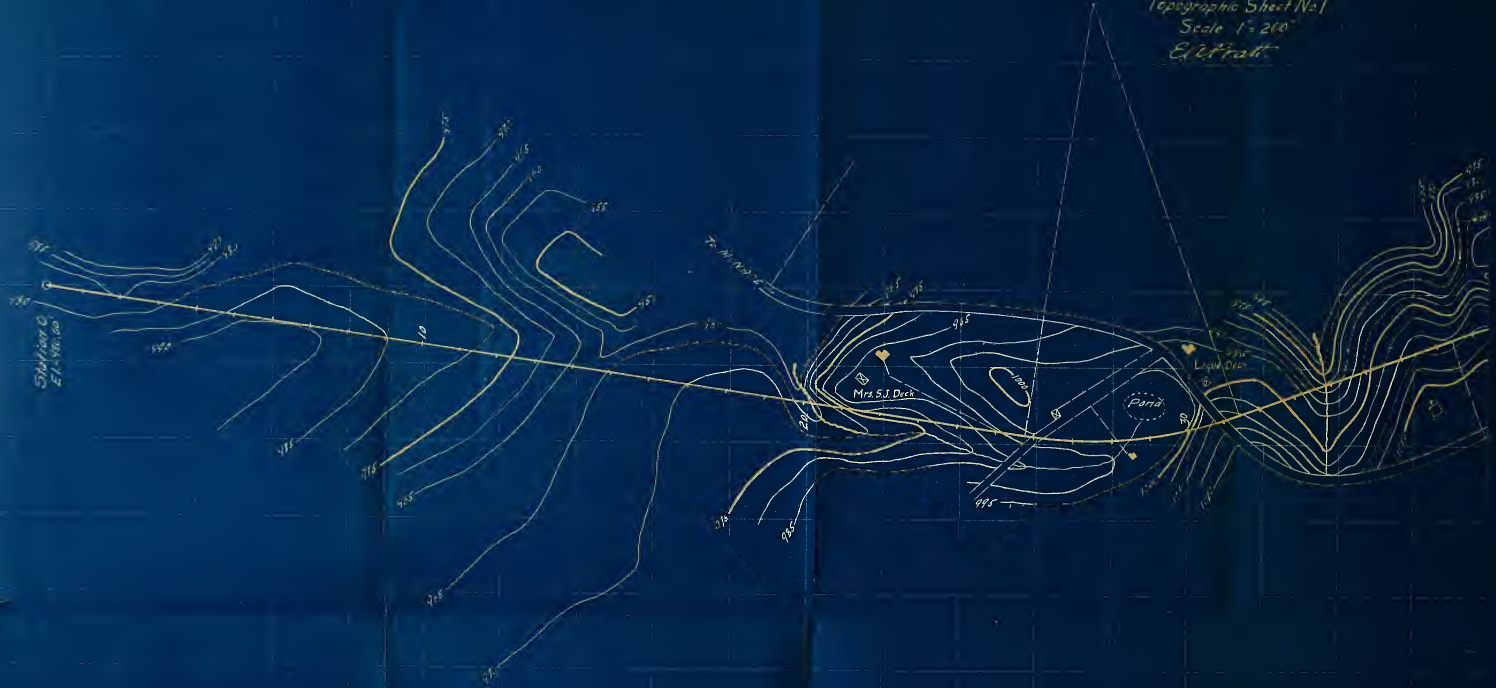
E.A. Pratt.

Location of O.C. R.R.

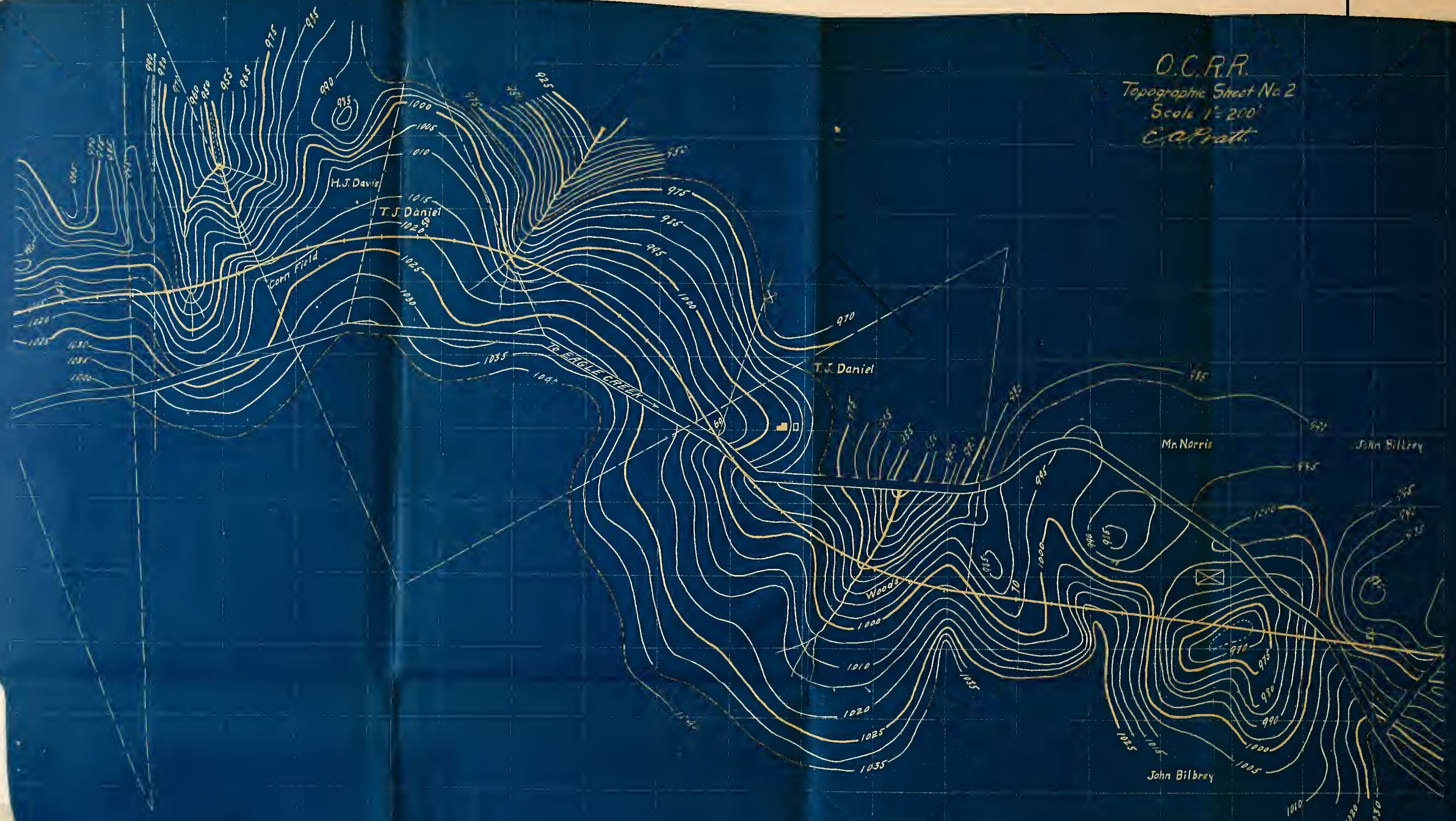
E.A. Pratt.

965
Mrs. S.J. De

O.C.R.R.
Topographic Sheet No. 1
Scale 1" = 200'
E.L. Pratt

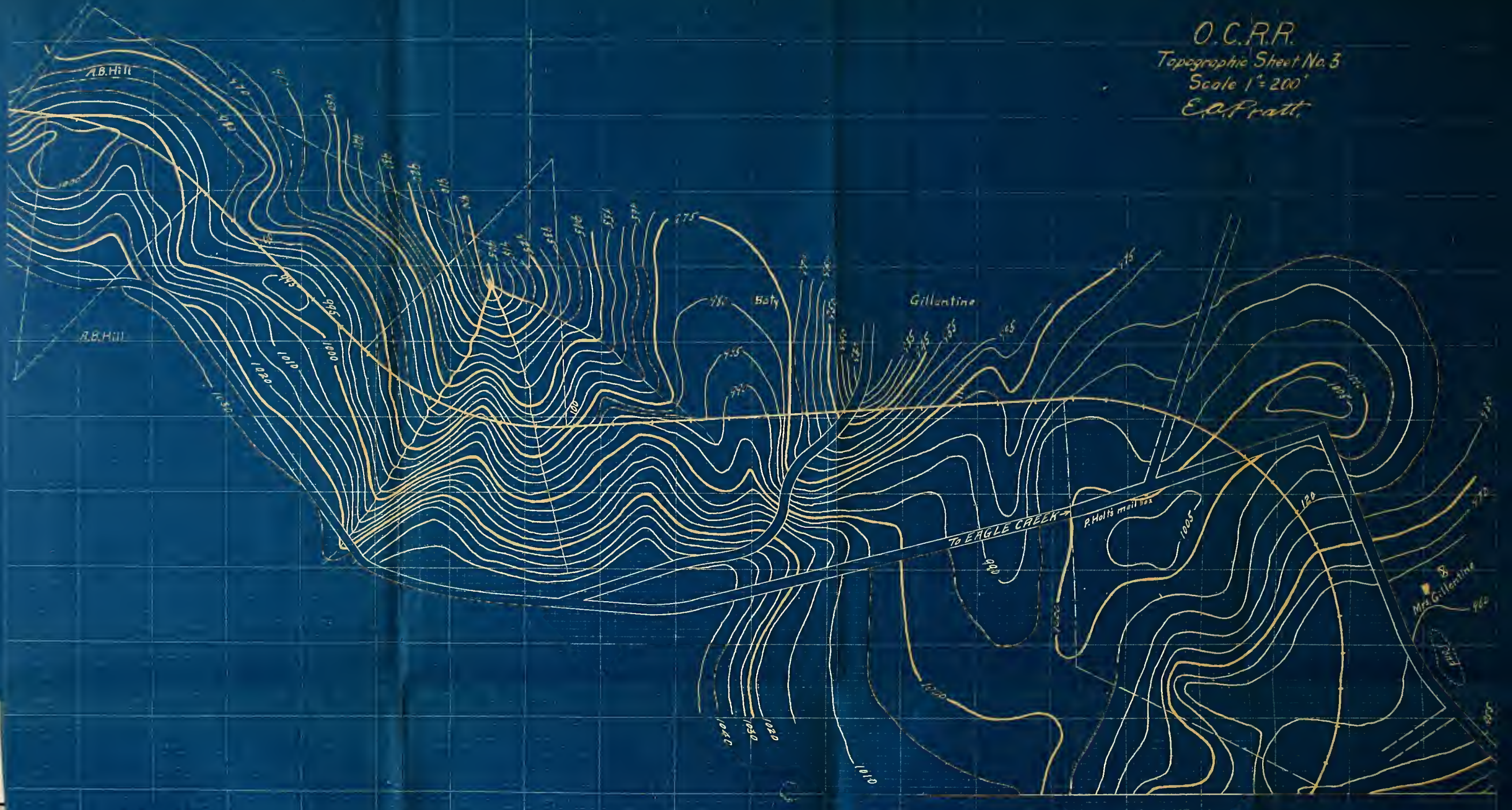


970
T.J. Daniel
975
965



O.C.R.R.
Topographic Sheet No 2
Scale 1"= 200'
C.A.Pratt

G
940
930
935
93

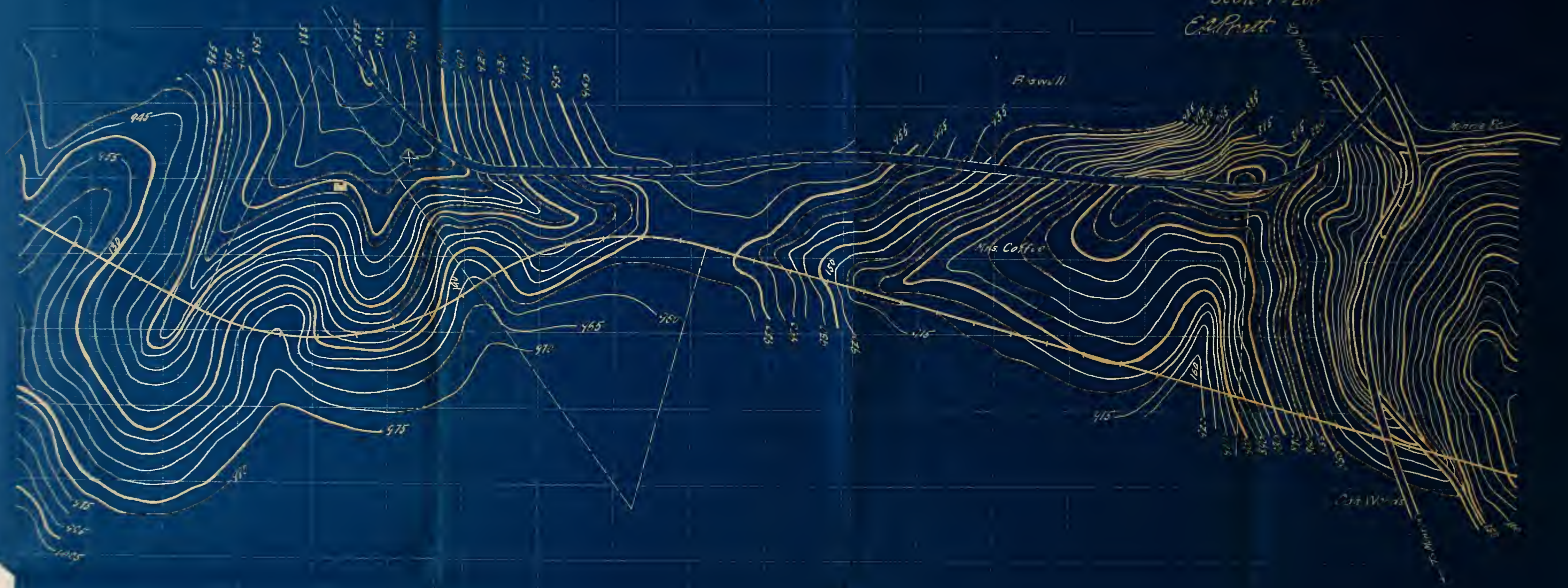

O.C.R.R.

Topographic Sheet No. 3

Scale 1" = 200'

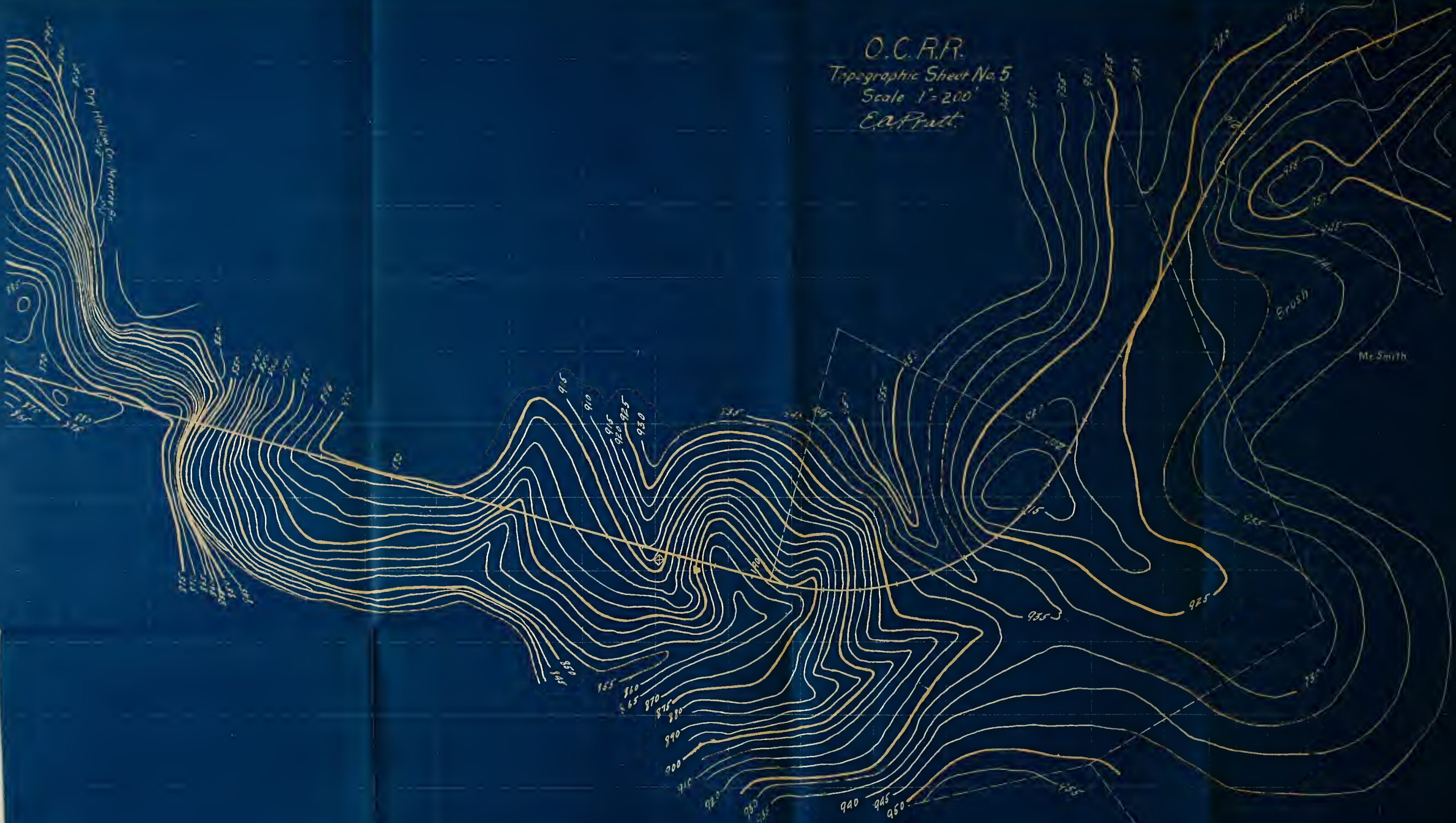
E.A. Pratt.

955

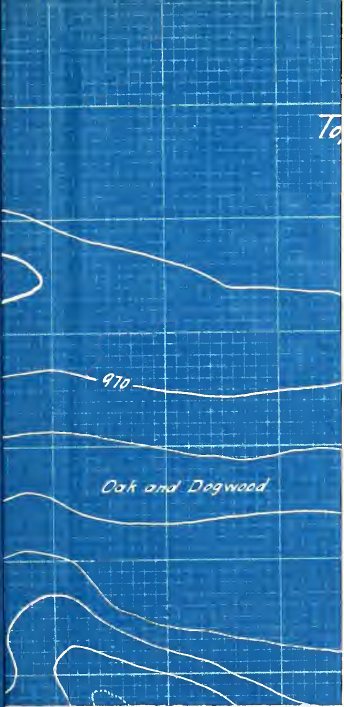


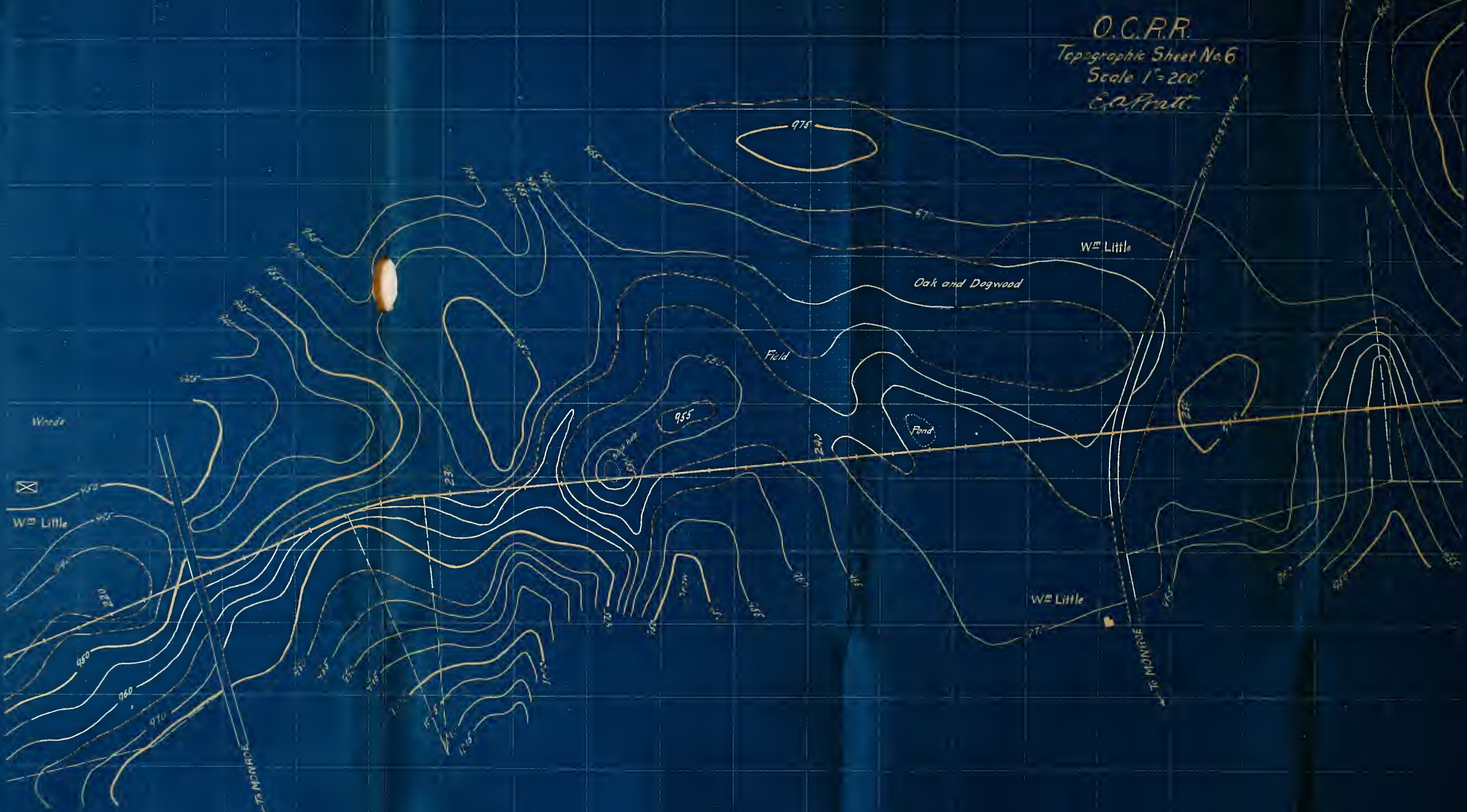
O.C.R.R.
Topographic Sheet No. 4
Scale 1" = 200'
E.Q. Pratt

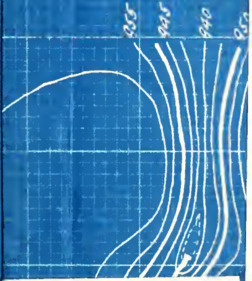
Topog



O.C.R.R.
Topographic Sheet No. 5
Scale 1" = 200'
E.A. Pratt


To
970
Oak and Dogwood


O.C.R.R.
Topographic Sheet No. 6
Scale 1"=200'
C.A. Pratt.
975
970
Wm Little
Oak and Dogwood
Field
955
Pond
Woods
Wm Little
950
945
940
220
230
240
950
960
970
To MONROE
To SYKROSTOWN
Wm Little
970
To MONROE

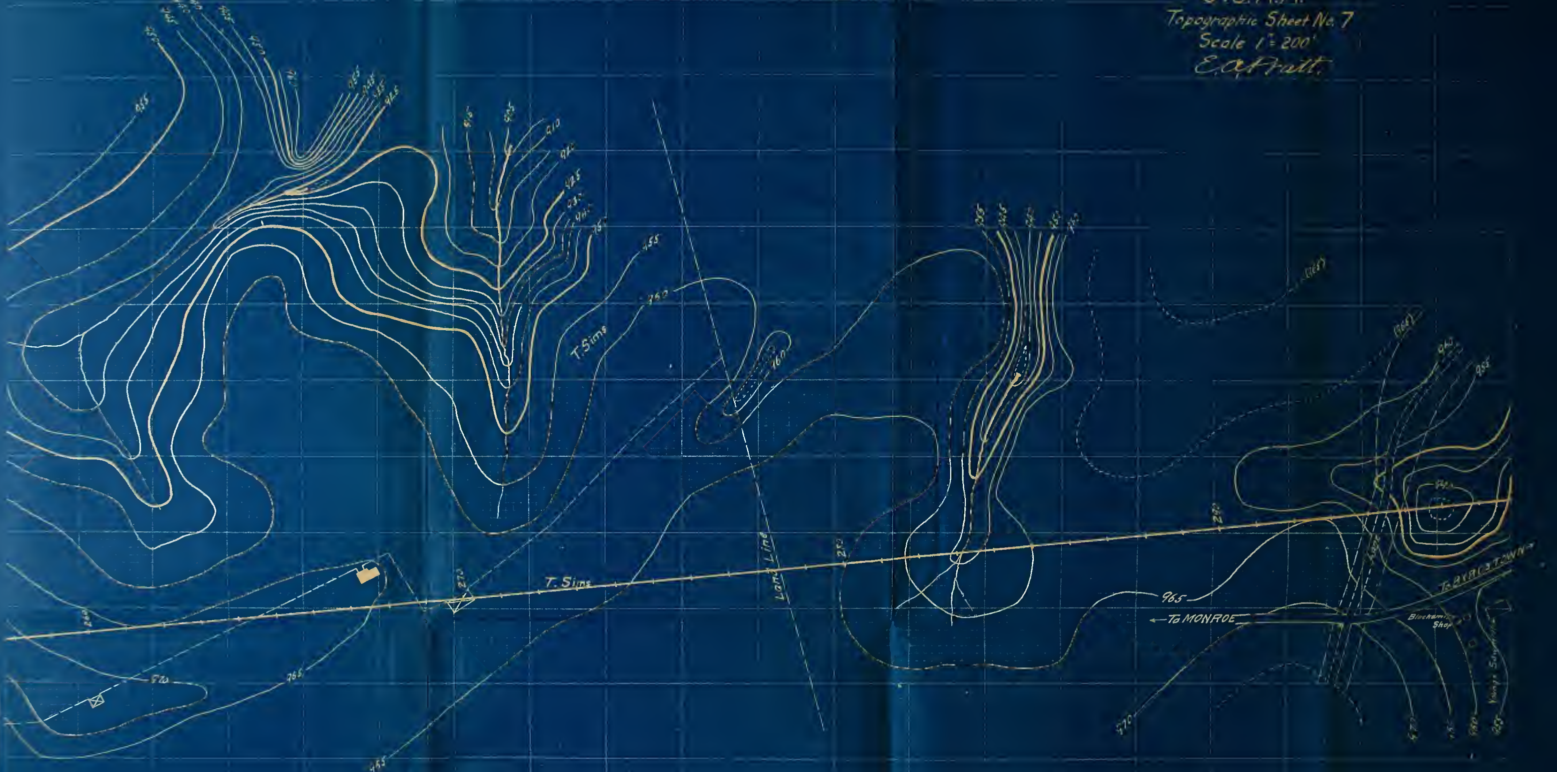

955
945
940
950

O.C.R.R.

Topographic Sheet No. 7

Scale 1" = 200'

E.A. Pratt.



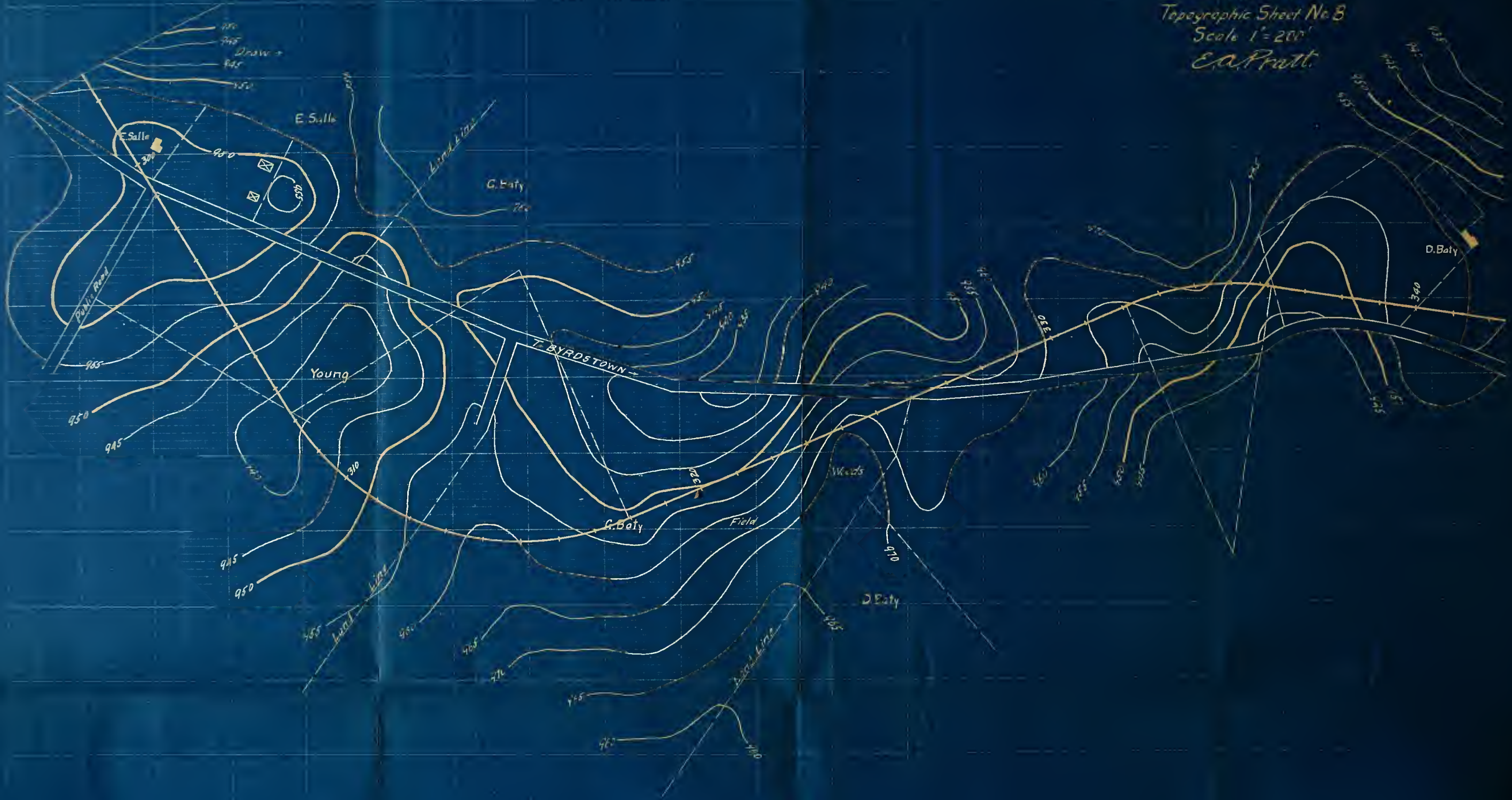
940
Wa

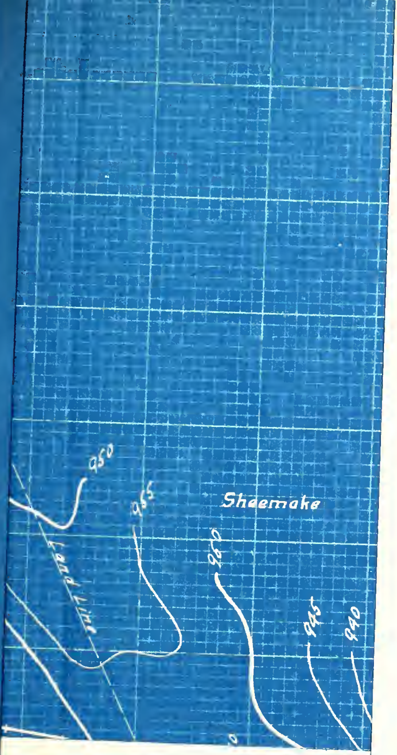
O.C.R.R.

Topographic Sheet No. 8

Scale 1" = 200'

E.A.Pratt.



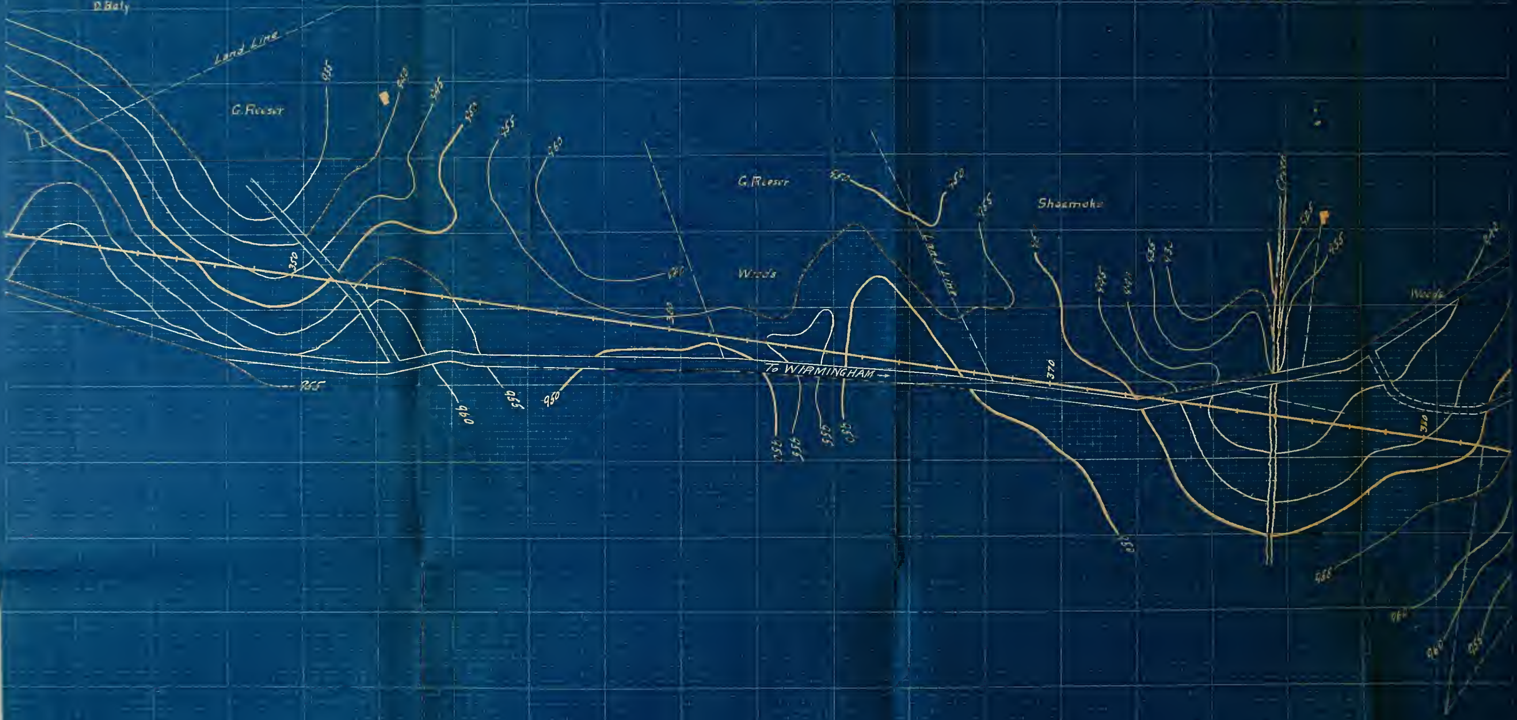

950
955
Sheemake
960
Land Line
945
940

O.C.R.R.

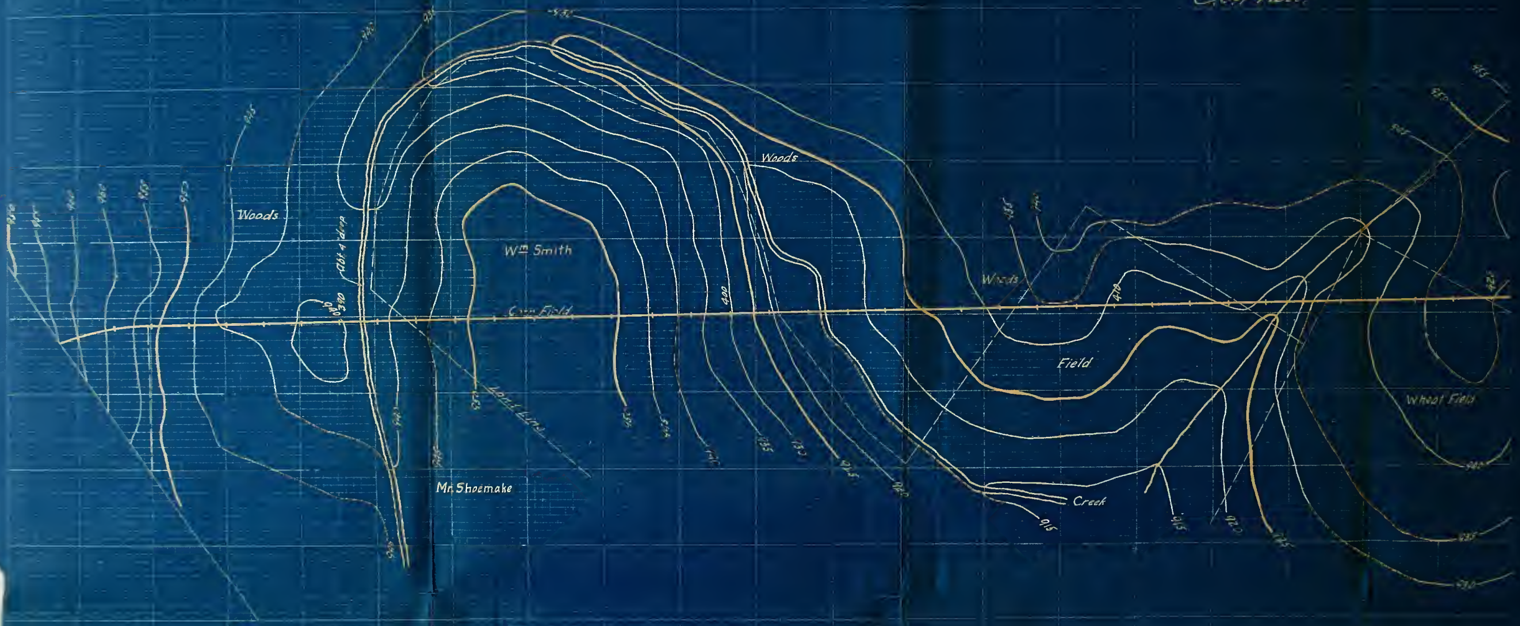
Topographic Sheet No. 9

Scale 1" = 200'

E.C. Pratt



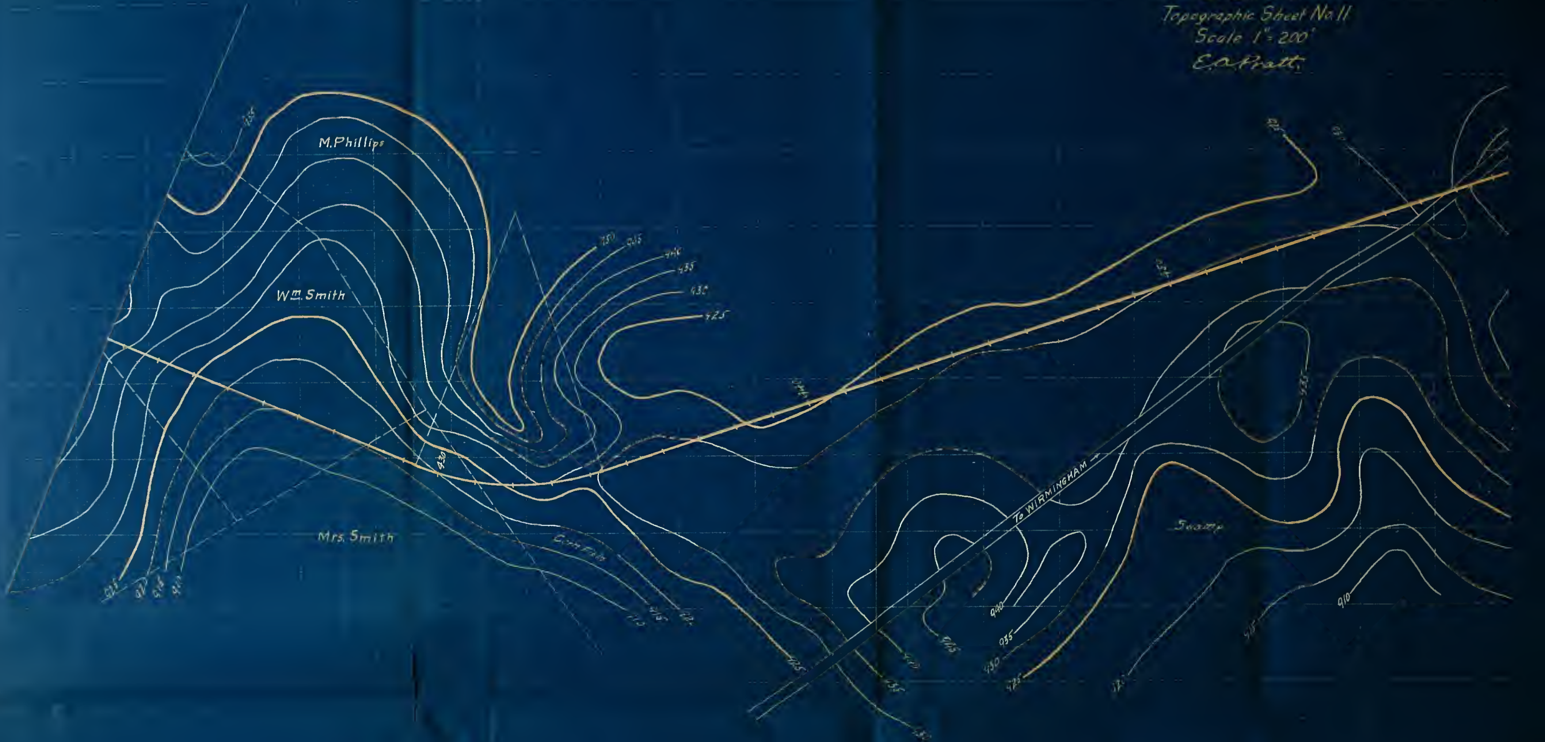
935
940
Woods
410
Field



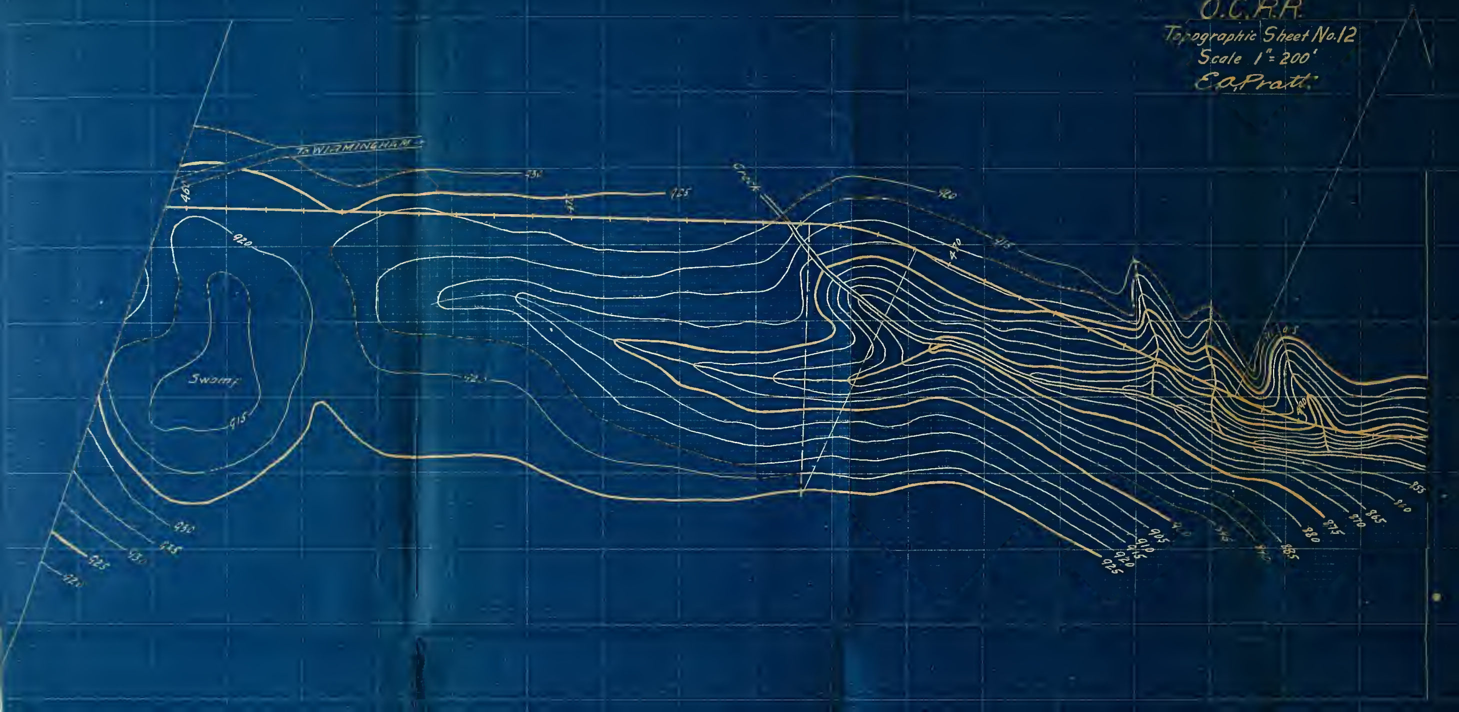
O.C.R.R.
Topographic Sheet No.10
Scale 1" = 200'
E.O.Pratt

O.C.R.R.

Topographic Sheet No. 11
Scale 1" = 200'
E. A. Pratt



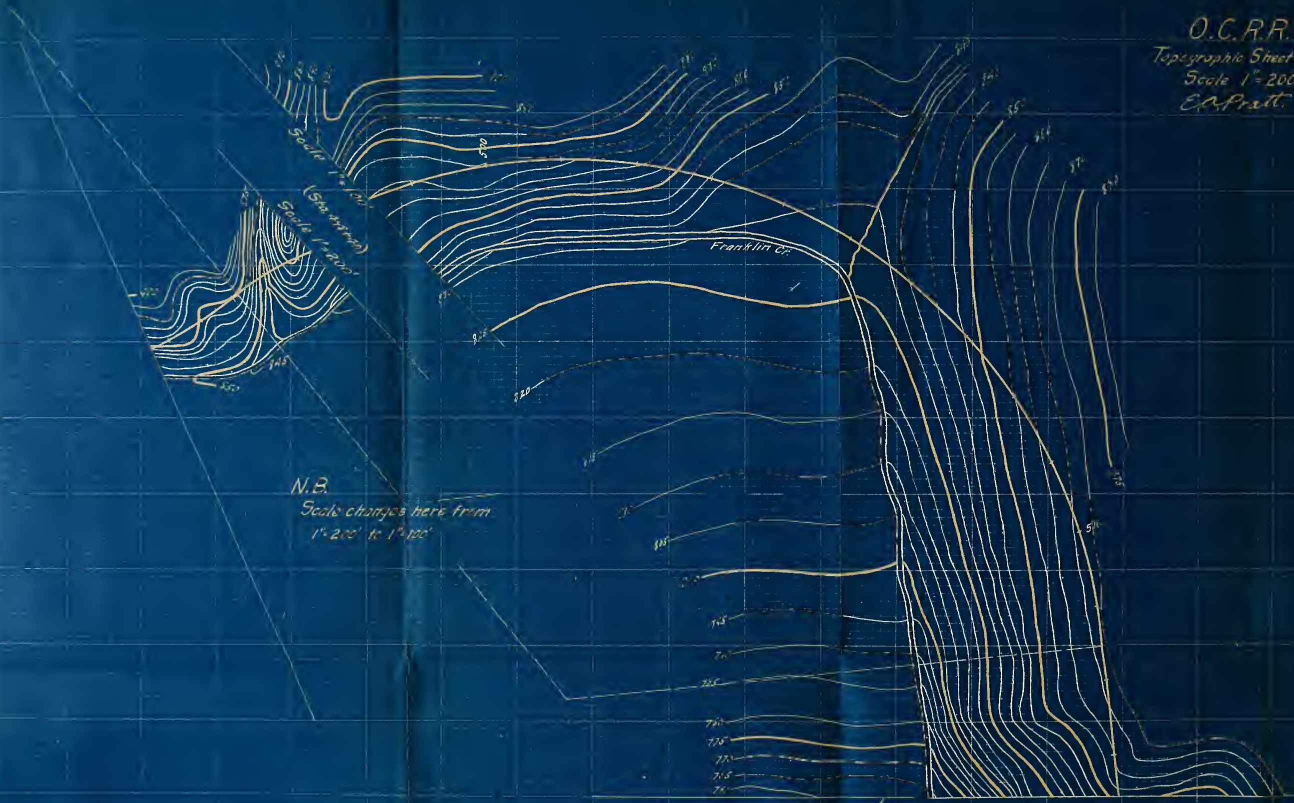
6 R
84 22
850
0
50
100
850



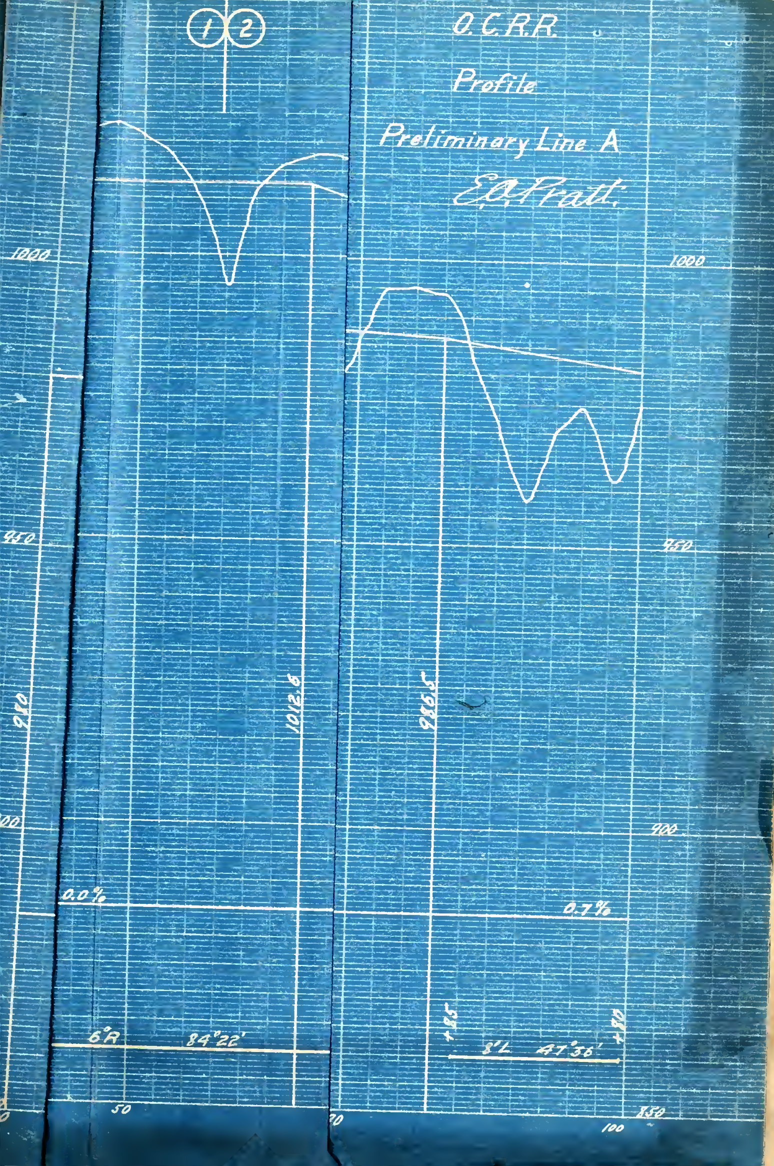
O.C.R.R.
Topographic Sheet No. 12
Scale 1" = 200'
E.A. Pratt.

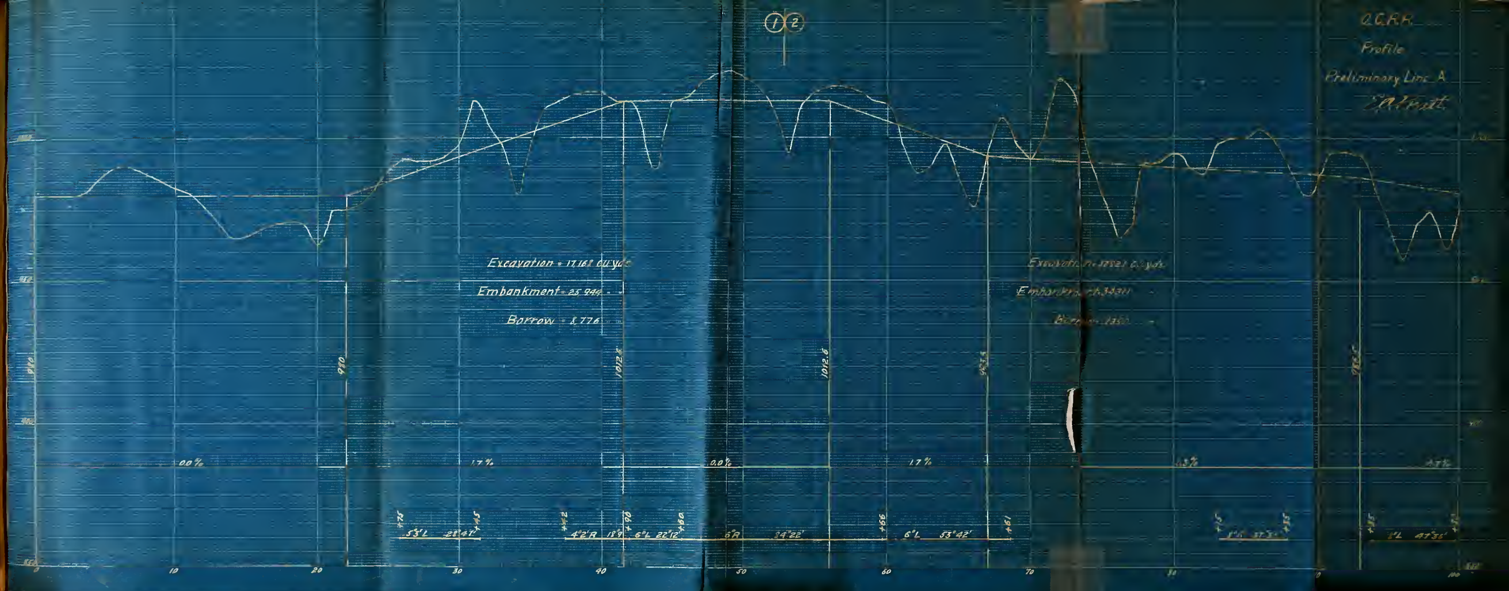
6°R
84°22'
850
0
50
100
850

O.C.R.R.
Topographic Sheet No. 13
Scale 1" = 200'
E.A.Pratt.

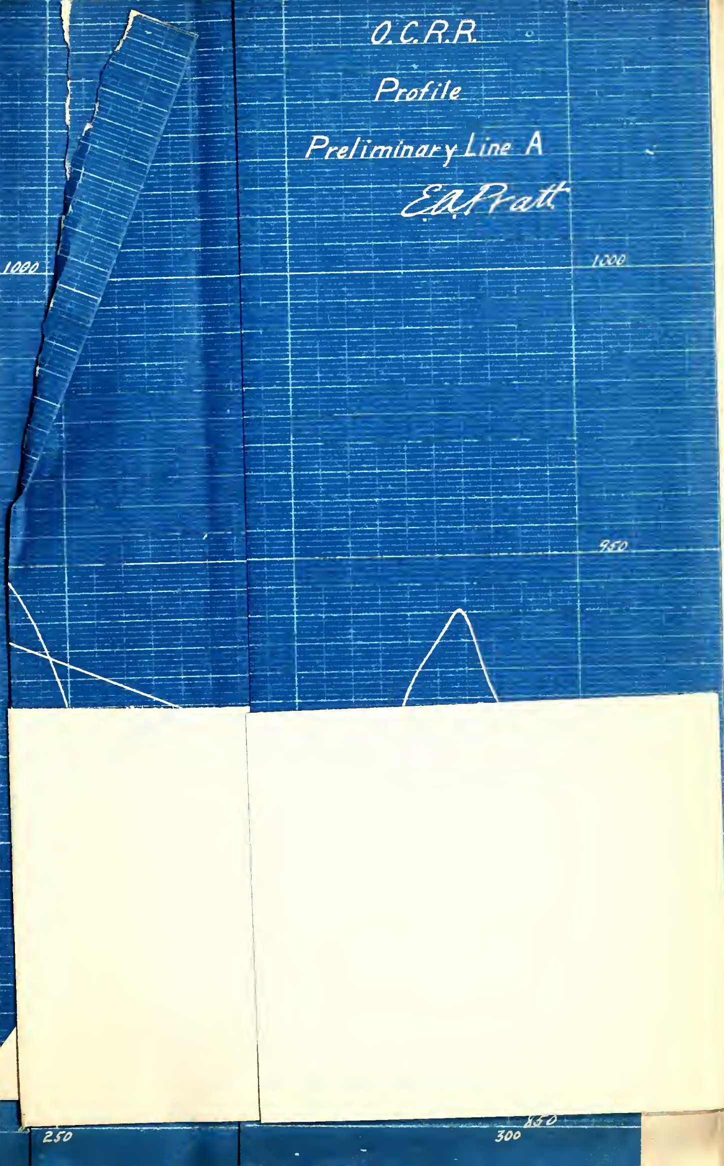


N.B.
Scale changes here from
1" = 200' to 1" = 100'

①②
O.C.R.R.
Profile
Preliminary Line A
E.O. Pratt.
1000
1000
950
950
960
1012.8
986.5
900
0.0%
0.7%
6°R 84°22'
+85
+80
8°L 47°36'
50
100
850



Q.C.R.R.
Profile
Preliminary Line A

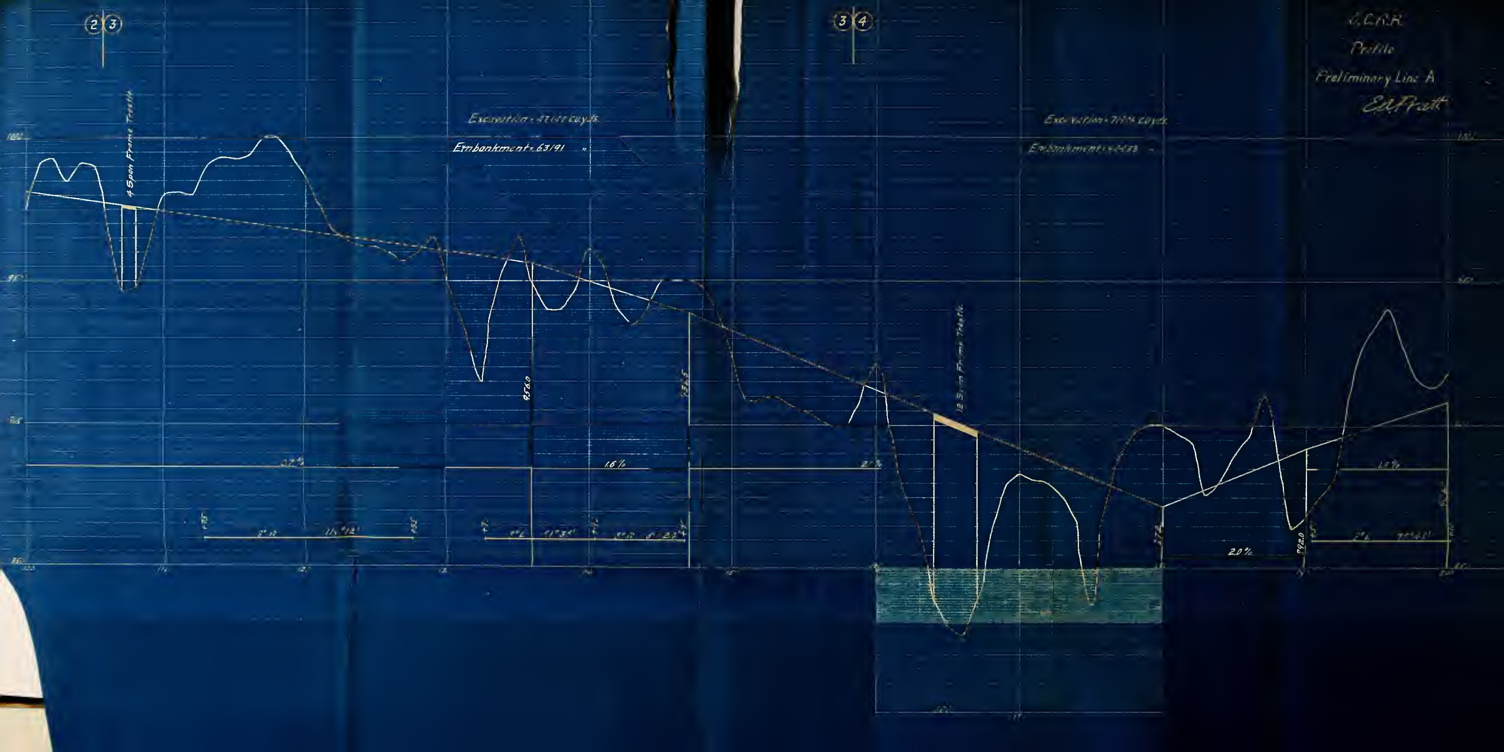


O.C.R.R.

Profile

Preliminary Line A

E.A. Pratt



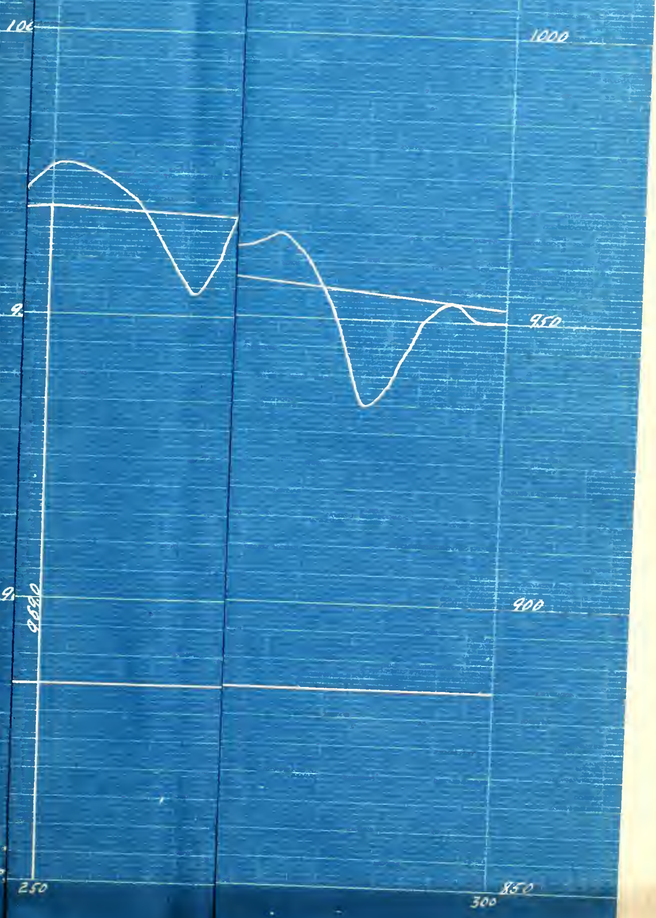
J.C.R.R.
Profile
Preliminary Line A
E.A. Pratt

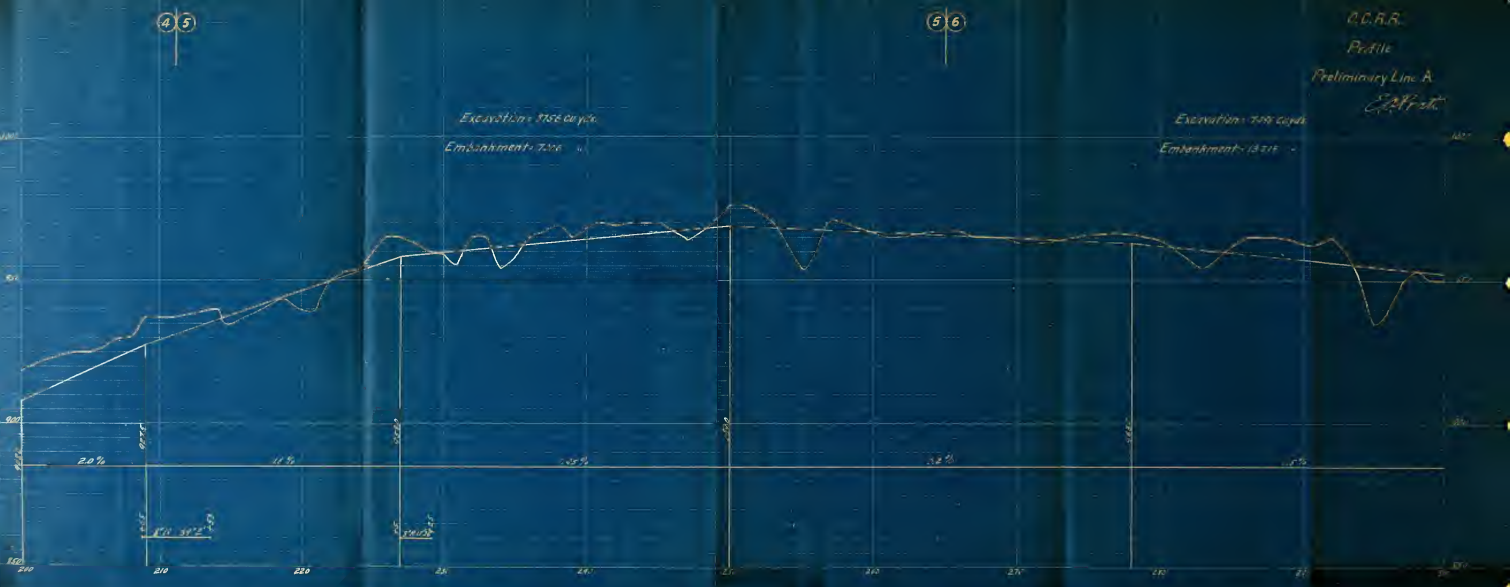
O.C.R.R.

Profile

Preliminary Line A

E.O. Pratt.

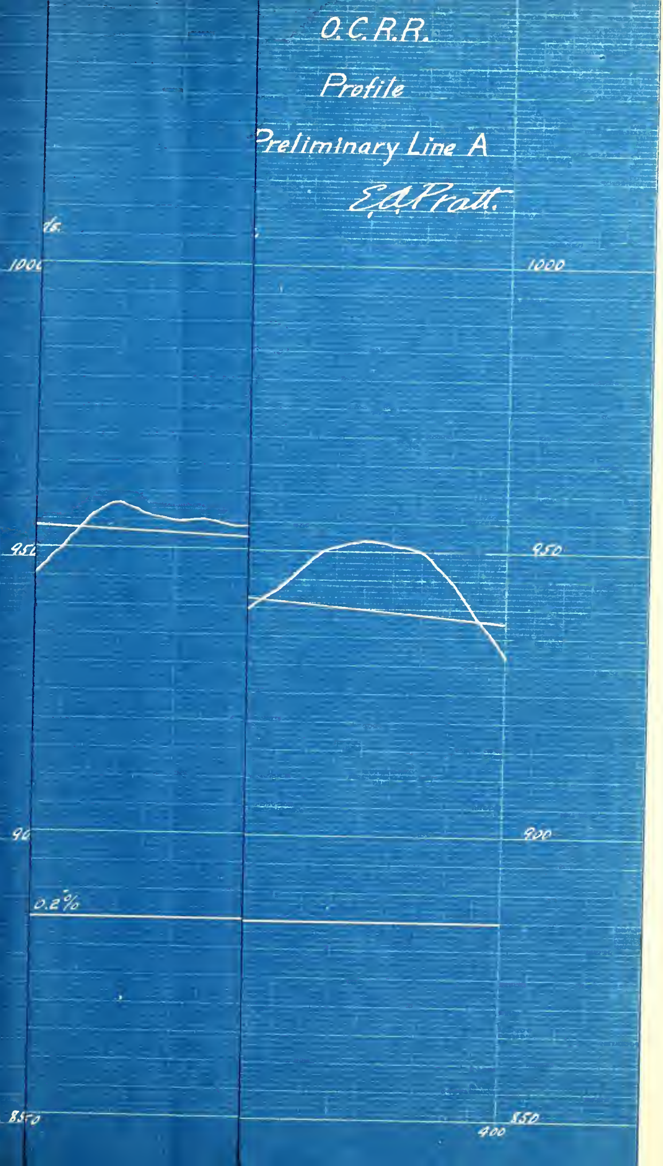




C.C.R.R.
Profile
Preliminary Line A.
E.C. Pratt

Excavation = 3756 cu yds.
Embankment = 7206 "

Excavation = 7496 cu yds.
Embankment = 13317 "

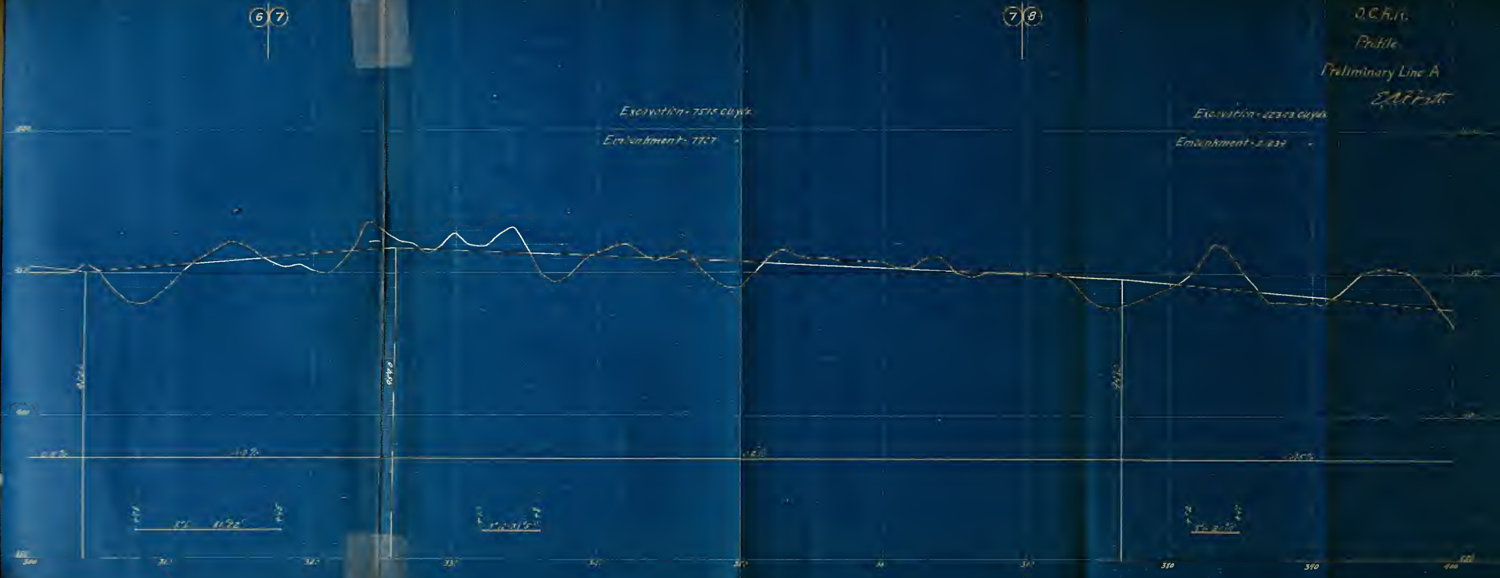


O.C.R.R.

Profile

Preliminary Line A

E.A. Pratt.


O.C.R.R.
Profile
Preliminary Line A
E.A.F. Pratt
Excavation - 7515 cu.yds.
Embankment - 7707
Excavation - 22343 cu.yds.
Embankment - 2237

cu.yds.

1000

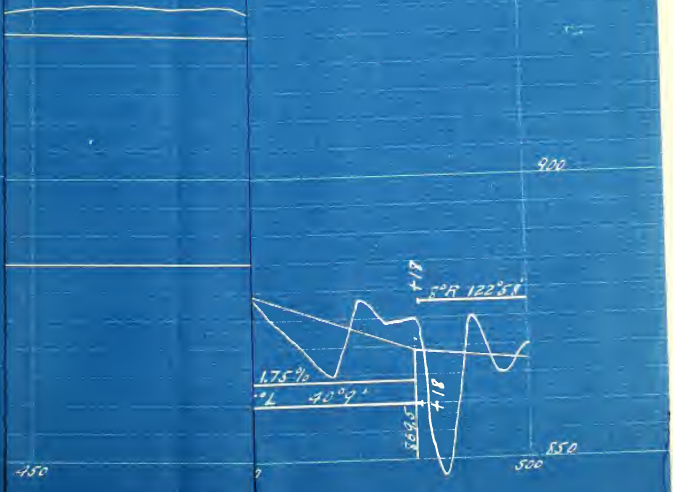
O.C.R.R.

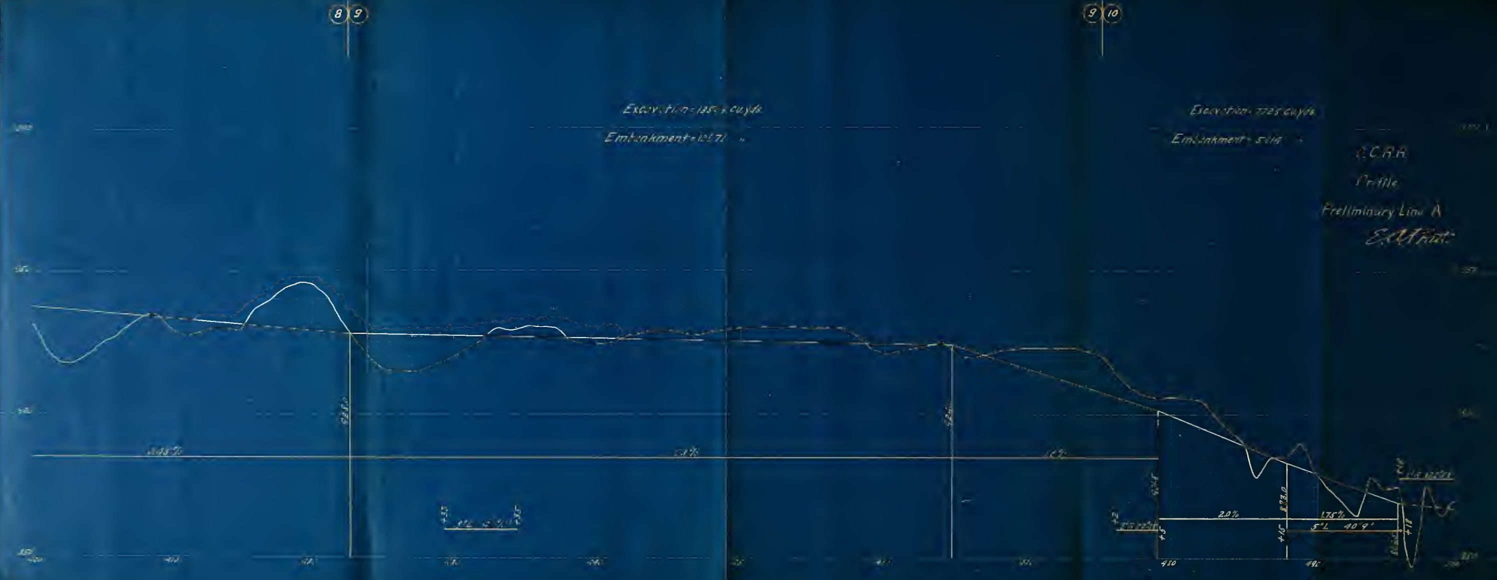
Profile

Preliminary Line A

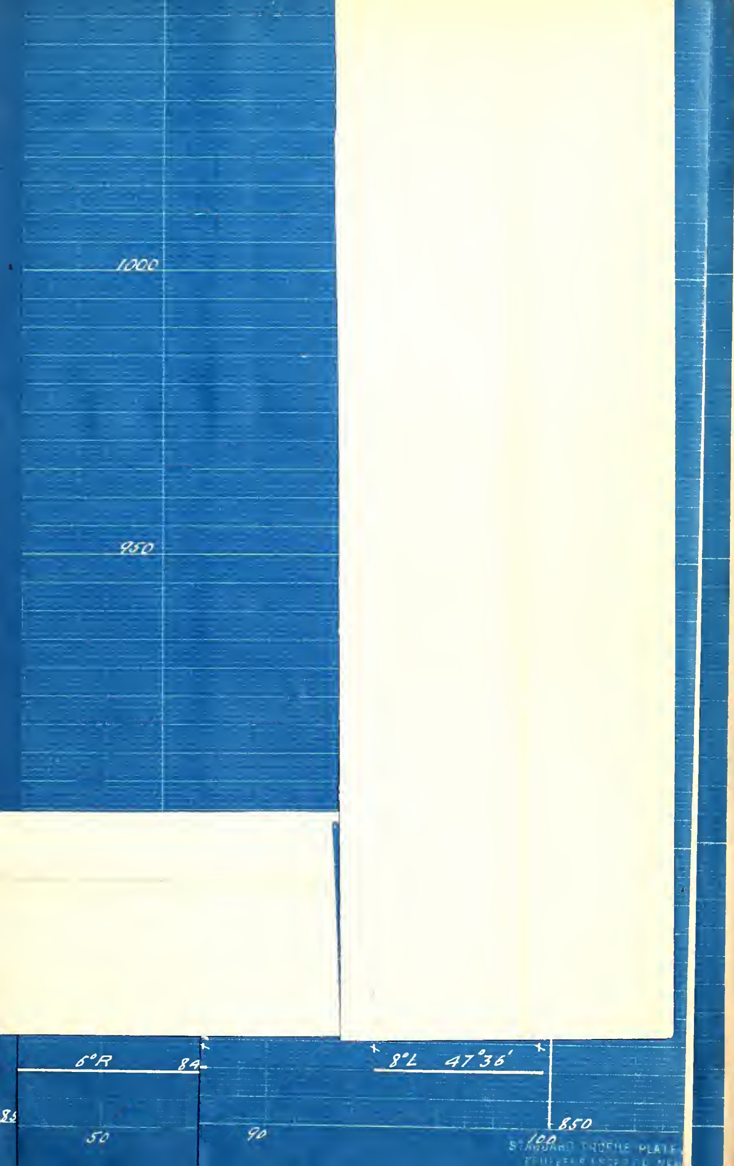
E.A. Pratt.

950





C.C.R.R.
Profile
Preliminary Line A
E.A.Pratt

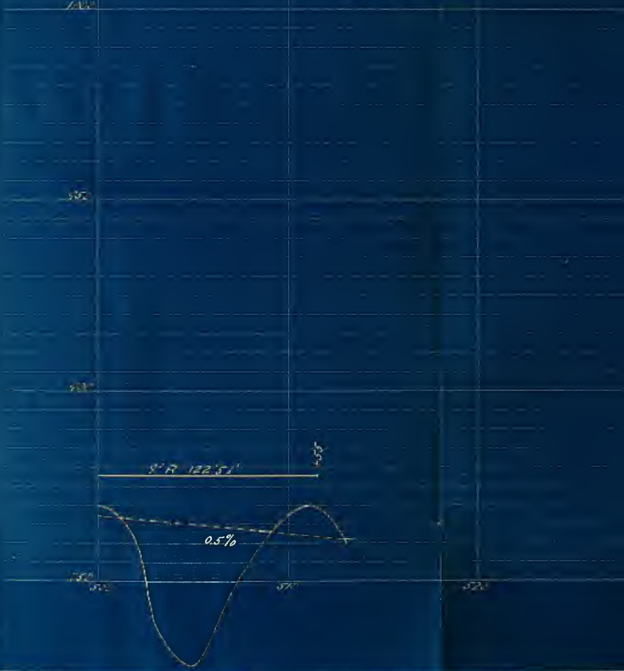

6°R
8°L 47°36'
STANDARD PROFILE PLATE

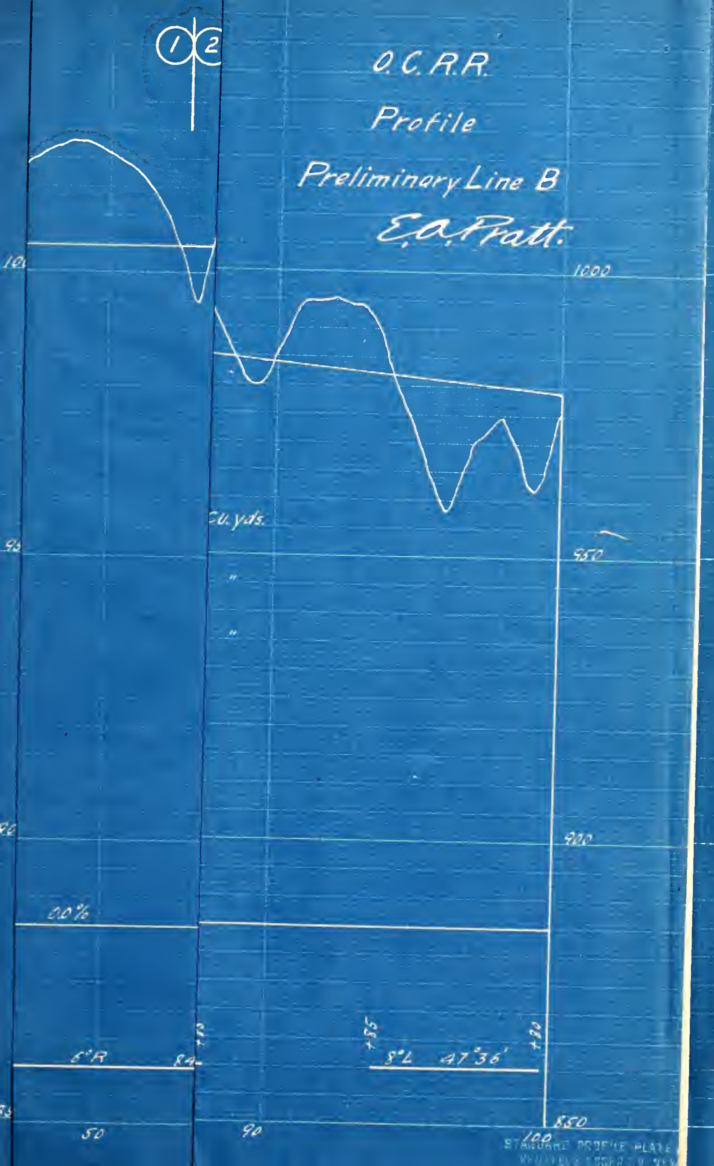
O.C.R.R.

Profile

Preliminary Line A

E.A.Pratt.



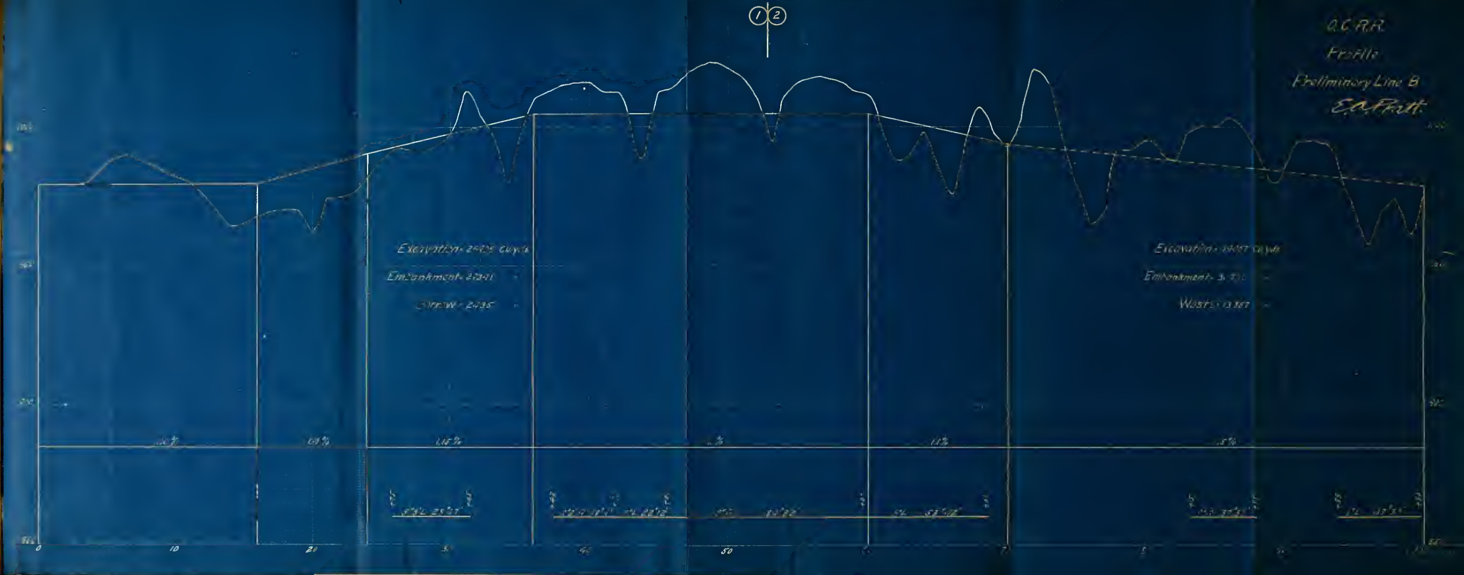


O.C.R.R.

Profile

Preliminary Line B

E.A. Pratt.

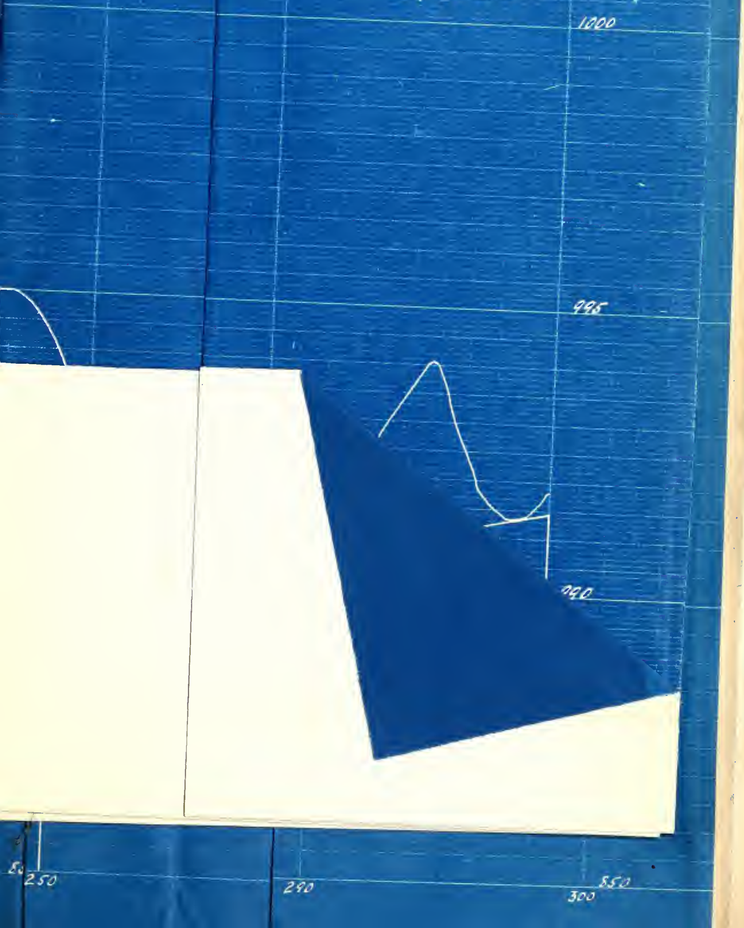

O.C.R.R.
Profile
Preliminary Line B
E.A. Pratt
1
2
Excavation = 24?05 cu.yds.
Embankment = 27341
Borrow = 2435
Excavation = 1?4?7 cu.yds.
Embankment = 3,???
Waste = 13,367
.16%
0.9%
1.15%
.2%
1.1%
.5%
0
10
20
30
40
50
6
7
8
9

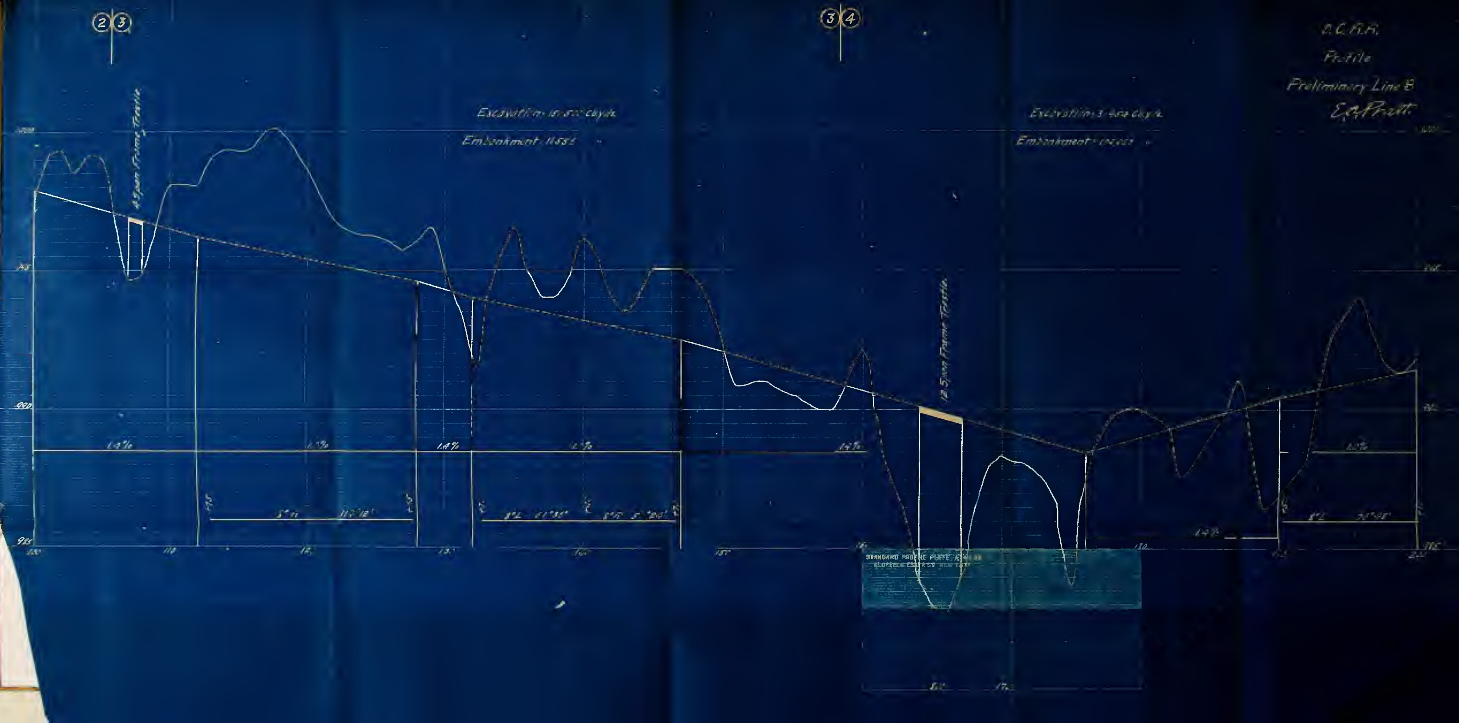
O. C. R.R.

Profile

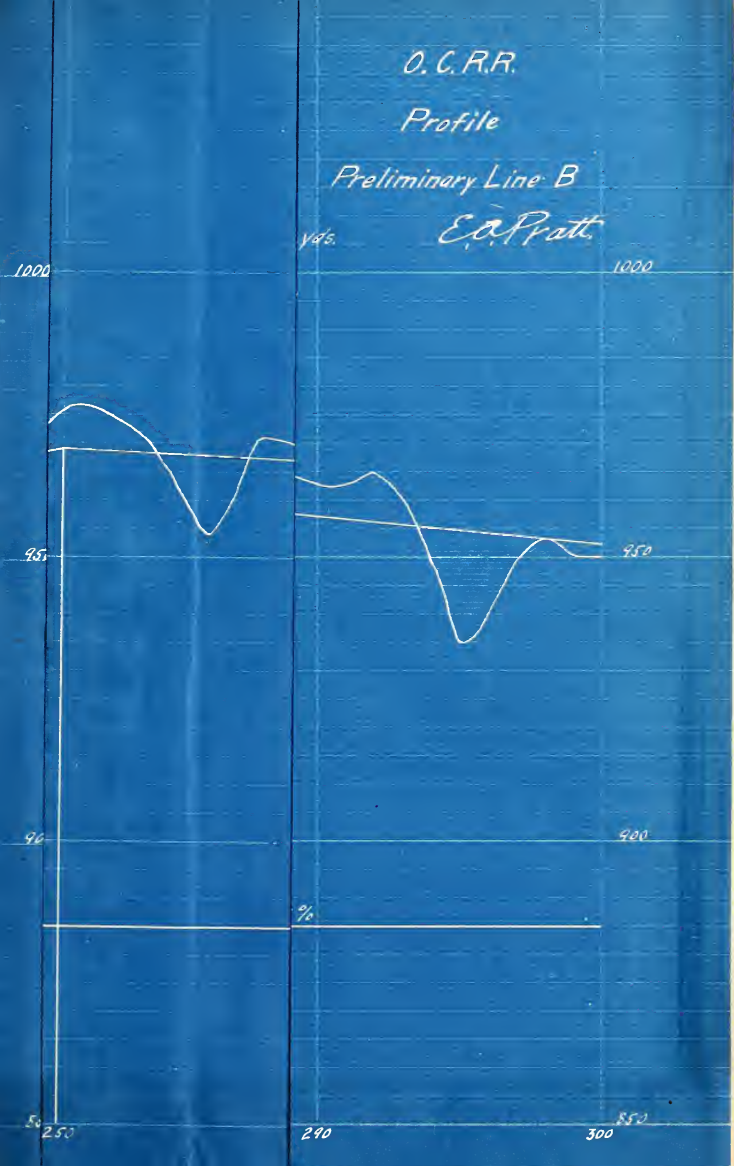
Preliminary Line B

E. O. Pratt.





O. C. R.R.
Profile
Preliminary Line B
E. A. Pratt.
②③
③④
4 Span Frame Trestle
12 Span Frame Trestle
Excavation 15,500 cu.yds.
Embankment 11,552 "
Excavation 3,402 cu.yds.
Embankment 104,052 "
1000
995
990
985
1.4%
1.0%
1.4%
1.0%
1.4%
1.4%
1.0%
5° R 117°12'
8° L 61°30'
8° R 5°24'
8° L 75°45'
100
110
120
130
140
150
160
180
200
STANDARD PROFILE PLATE
KEUFFEL & ESSER CO. NEW YORK

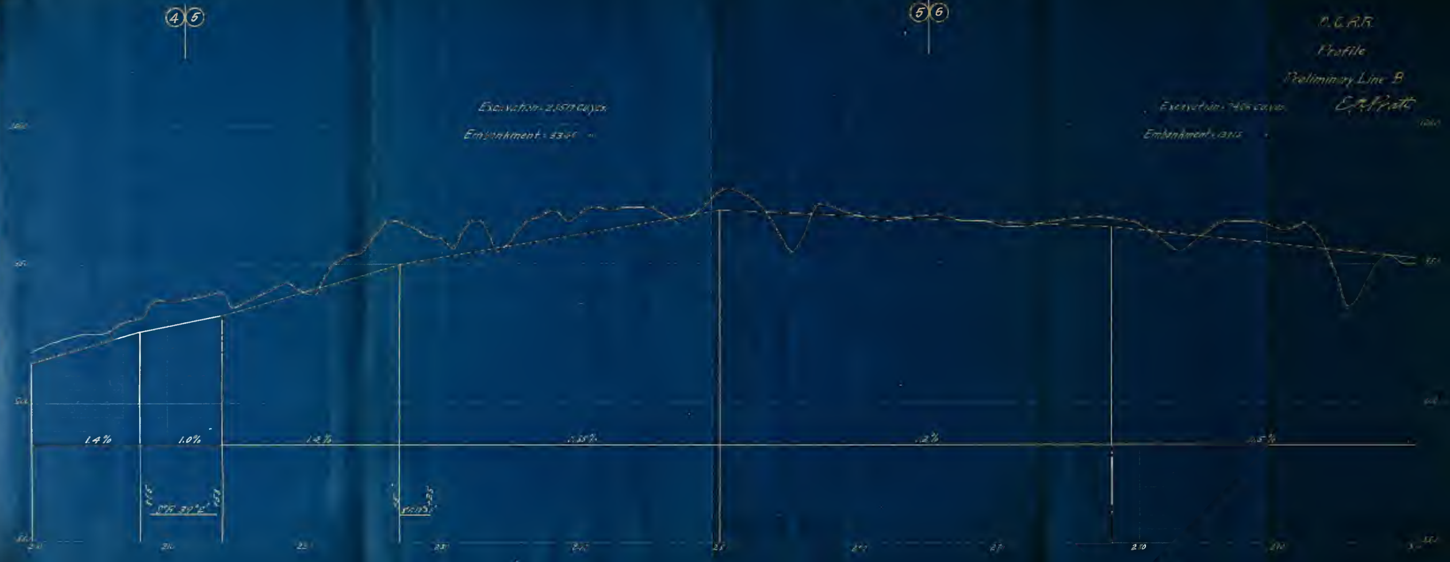


O. C. R.R.

Profile

Preliminary Line B

E. O. Pratt



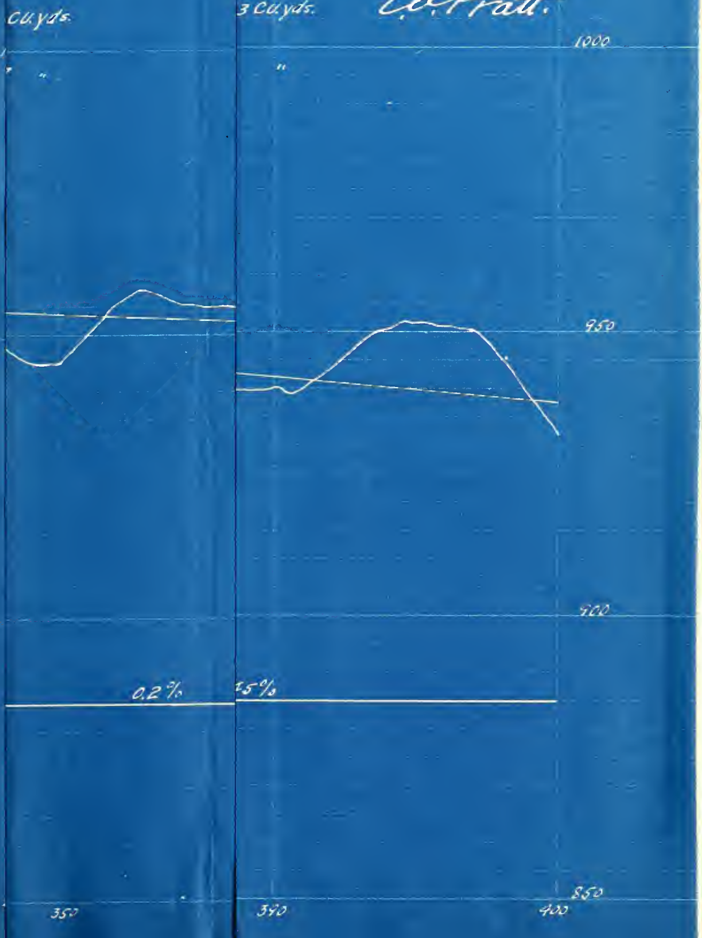
O. C. R.R.
Profile
Preliminary Line B
E. Pratt

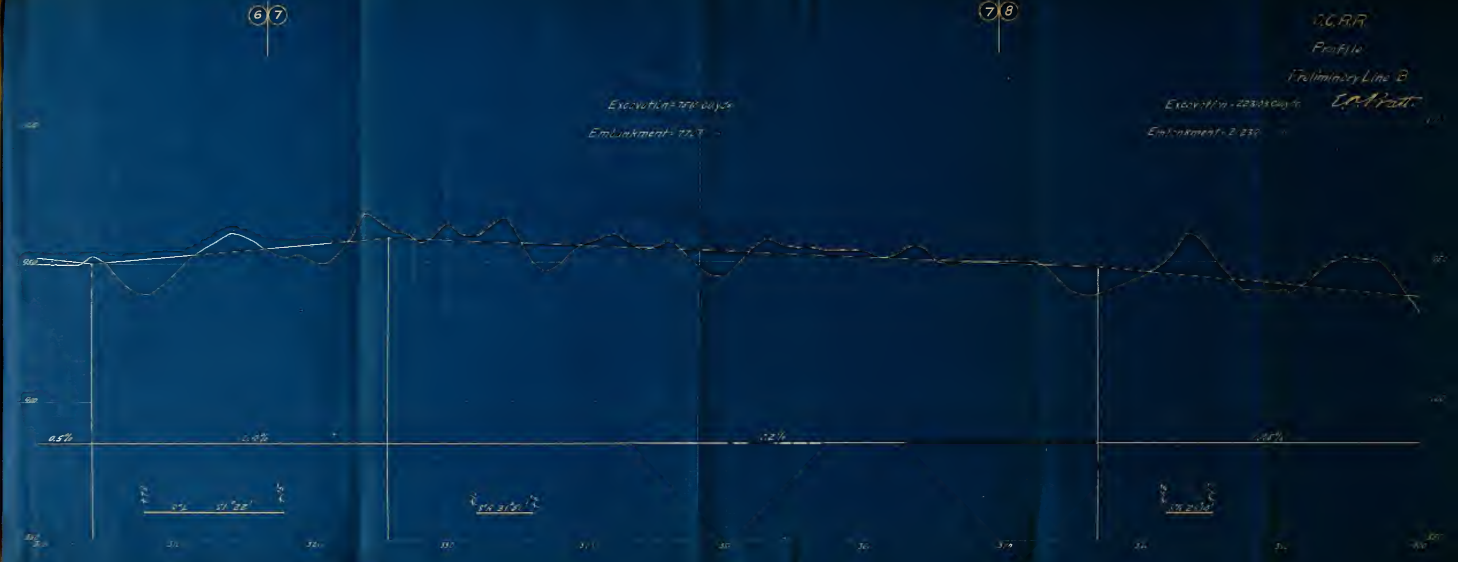
O.C.R.R.

Profile

Preliminary Line B

E.O. Pratt.



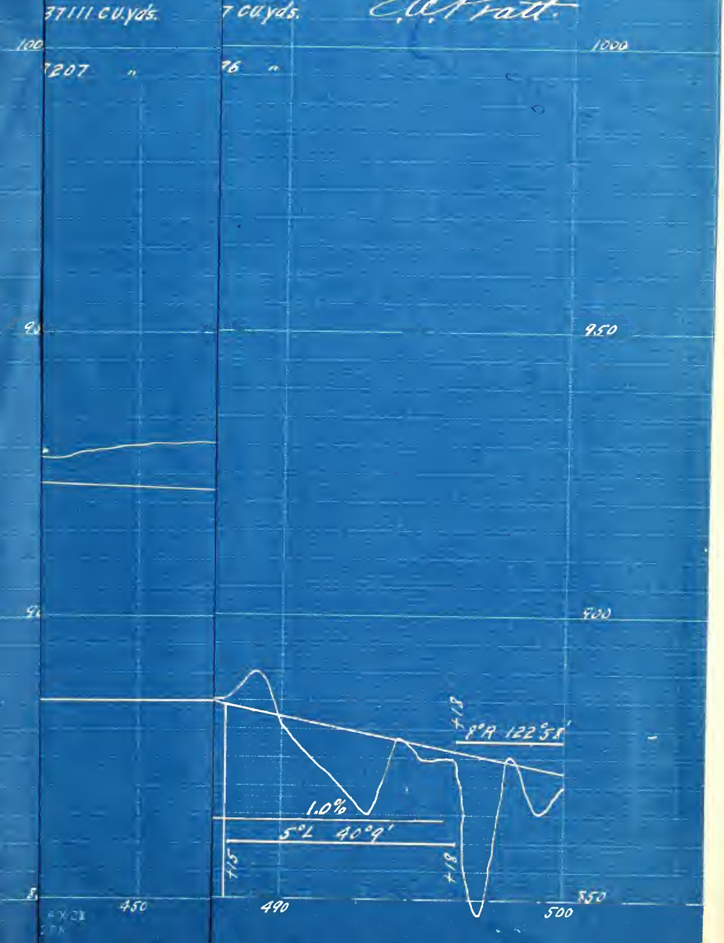

6
7
7
8
O.C.R.R.
Profile
Preliminary Line B
E.C. Pratt
Excavation =
Embankment = 77.7
Excavation - 223.05 Cu.yds.
Embankment - 2.230
950
900
0.5%
0.4%
.12%
.05%

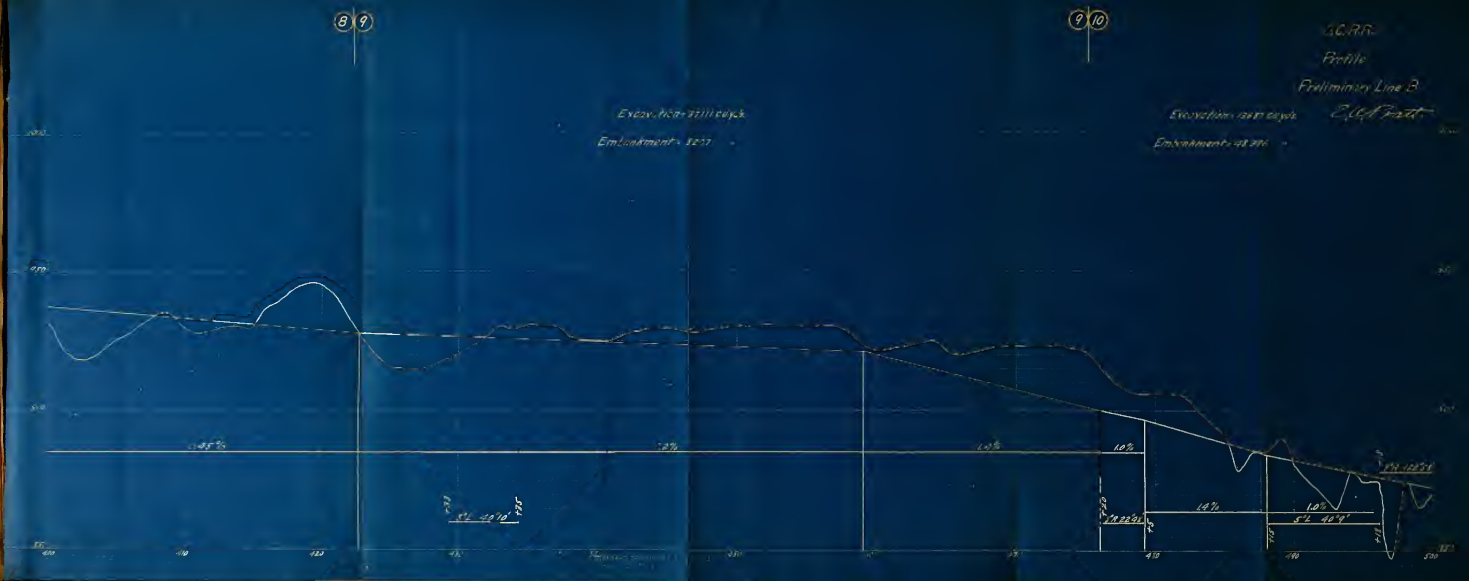
O.C.R.R.

Profile

Preliminary Line B

E.A. Pratt.





A.C.R.R.

Profile

Preliminary Line B

E.C.A. Pratt

Excavation = 37111 cu.yds.

Embankment = 3217 "

Excavation = 13687 cu.yds.

Embankment = 48396 "

1000
950
900

O. C. R. R.

Profile

Preliminary Line B

E. A. Pratt